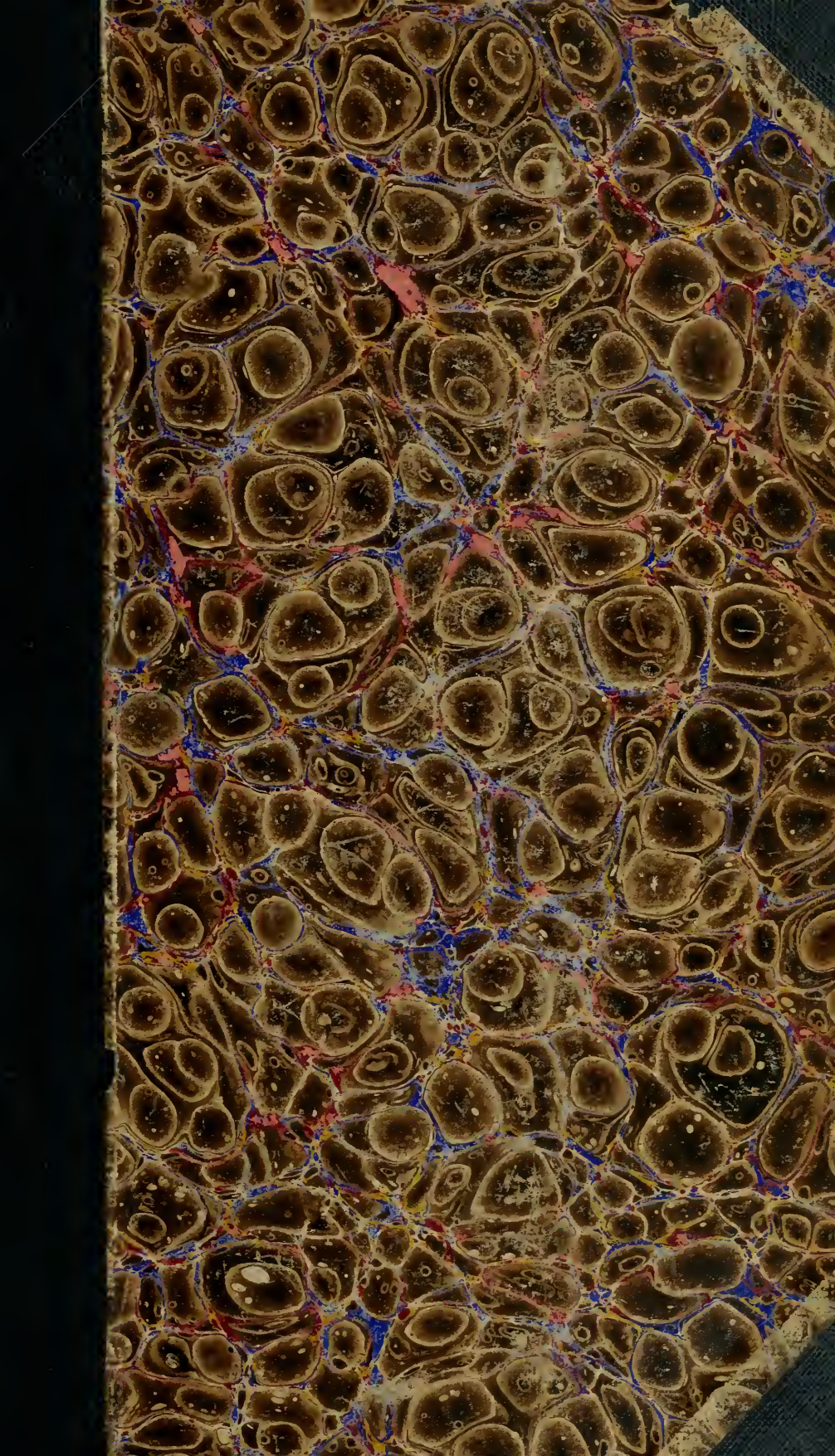

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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

# TRANSACTIONS.

## VOL. XXXVIII.

1888–9.

NEWCASTLE-UPON-TYNE:
ANDREW REID, SONS AND CO., PRINTERS, &C., 50, GREY STREET
1891.

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## ADVERTISEMENT.

THE INSTITUTE is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

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# CONTENTS OF VOL. XXXVIII.


| | PAGE. |
|---|---|
| ADVERTISEMENT | ... |
| CONTENTS | i |
| REPORT OF COUNCIL | iii |
| REPORT OF FINANCE COMMITTEE | vii |
| TREASURER'S ACCOUNTS | viii |
| ACCOUNT OF SUBSCRIPTIONS | x |
| GENERAL STATEMENT | xii |
| COURSE OF INSTRUCTION FOR MINING ENGINEERS, AT THE DURHAM COLLEGE OF SCIENCE | xiii |
| PATRONS | xv |
| HONORARY MEMBERS | xv |
| OFFICERS | xvii |
| MEMBERS | xviii |
| ASSOCIATE MEMBERS | xxxi |
| ASSOCIATES | xxxi |
| STUDENTS | xxxii |
| SUBSCRIBERS | xxxiv |
| CHARTER | xxxv |
| BYE-LAWS | xl |


## MEETINGS.


| 1888. | PAGE. |
|---|---|
| Oct. 13.—General Meeting | 1 |
| "The Danger attending the use of Light Mineral Oils for Lubricating Air-Compressing Machinery." By Mr. John Morison | 3 |
| Discussed | 7 |
| "Charles Pit—Flaggy Creek Pit Heading: Description of the Survey." By Mr. Jas. Hunter | 13 |
| Discussed | 16 |
| Remarks by the President on his Election | 17 |
| Electric Miners' Lamp exhibited by the New Portable Electric Lamp and Power Syndicate | 17 |
| Discussed | 17 |
| Nov. 8.—Visit to Seaton Carew Diamond Bore-hole | 21 |
| "Notes on the Seaton Carew Boring." By Mr. W. J. Bird | 21 |
| Dec. 8.—General Meeting | 27 |
| President's Address | 29 |
| 1889. | |
| Feb. 9.—General Meeting | 47 |
| "Notes on the Variations in the Faulting of Coal, observed in the Action of the same series of Faults in three Seams at Redheugh Colliery." By Mr. T. O. Robson | 49 |
| Discussed | 52 |
| "Outbursts of Gas in Metalliferous Mines." By Mr. Bennett H. Brough | 59 |
| Discussed | 70 |
| Apparatus for use in Mines, for obtaining readings from Barometers, etc., placed at a distance. Exhibited by Mr. T. J. Murday | 72 |
| April 13.—General Meeting | 75 |
| The Federation of Mining Institutes | 76 |
| Proposed Alteration of Bye-laws | 76*a* |

| 1889. | | PAGE. |
|---|---|---|
| April 13.—Continued— | | |
| | Discussed ... ... ... ... ... ... ... .. ... | 76*b* |
| | "Coal Mining at Warora, Central Provinces, East India." By Mr. C. Z. Bunning ... ... ... ... ... ... ... | 77 |
| | Discussed ... ... ... ... ... ... ... ... ... | 169 |
| | "The Gold-fields of the Valley of De Kaap, Transvaal, South Africa." By Mr. J. M. Liddell .. ... ... ... ... | 171 |
| | "The Pieler Spirit Lamp as a Fire-damp Indicator." By Mr. M. Walton Brown ... ... ... ... ... ... ... | 177 |
| | Discussed ... ... ... ... ... ... ... ... ... | 182 |
| June 8.—Special General Meeting... . ... ... .. ... ... | | 183 |
| | Revision of Bye-laws ... ... ... ... ... ... ... | 183 |
| ,, | General Meeting ... ... ... ... ... ... ... ... | 187 |
| | "Notes of Reports on the Winning of the High Main Coal at Gosforth Colliery, on the South Side of the Ninety Fathom Dyke; and of the Winning of that Seam by Pits sunk on the South Side of the Dyke, and drifting through that Dyke to Win the Coal on the North Side, with Extracts from the various Reports relating thereto." By Mr. T. W. Embleton... | 189 |
| | Discussed ... ... ... ... ... ... ... ... ... | 201 |
| | "An Account of Experiments on the Resistance to Air Currents in Mines." By Mr. T. L. Elwen... ... ... ... .. | 205 |
| | Discussed ... ... ... ... ... ... .. ... ... | 216 |
| Aug. 3.—Annual General Meeting ... ... ... ... ... . | | 219 |
| | "The Economical Working of Steam Boilers at Collieries." By Messrs. W. Armstrong, Jun., and W. J. Bird... ... ... | 221 |
| | Discussed ... ... ... .. ... ... ... ... .. | 223 |

Barometer and Thermometer Readings for the year 1888 ... ... ... 229
Abstracts of Foreign Papers ... ... ... ... ... ... .. ... 1
Index ... ... ... ... ... ... ... ... ... ... ... 73

# Report.

In rendering an account of their stewardship during the past year, the Council feel that much has been done in that time, the fruits of which must be awaited for in the future before they can be properly appreciated. In their last Report several proposed changes in the working of the Institute were mentioned as occupying the attention of the Council. Prominent among these were two new schemes, one for improving the conditions of Membership of the Institute, and the other for the Federation for certain purposes of several of the Mining Institutes of the country. Both proposals have now become facts. A new set of Bye-Laws has been passed, the principal effects of which will be (1) the abolition of the three guinea subscription now paid by Ordinary Members; (2) the grouping of all existing, original, ordinary, and professional Associate Members into one professional class of Members, with a subscription of two guineas; (3) the retention of the class of Associate Members also paying two guineas, but restricted to persons not professionally connected with Engineering; and (4) the formation of a new class of Associates paying one guinea only, and consisting of such persons as occupy subordinate positions in the Mining and Engineering professions. It is hoped that this new class will prove a popular one, and will add greatly to the efficiency of the Institute.

As regards the Federation Scheme, the Council have to report that the Chesterfield, Midland, and South Staffordshire Institutes have united with the North of England Institute for one year to publish joint Transactions and Proceedings, and to hold four joint meetings. The chief results of this arrangement to this Institute at present will be (1) the receipt, without extra subscription, of the papers read at all the Federated Institutes, and (2) the periodical meeting on equal terms between the members of these bodies alternately at the seat of each, also yearly in London. The Council cannot but feel, however, that should this scheme

work satisfactorily, it must probably lead to results of far greater importance, and to the gradual growth of a truly National Institution of Mining Engineers.

The first meeting of the General Council of the Federated Institution will take place in this city in September next during the British Association week, and the first general joint meeting of the various Institutes in January, 1890.

The following have been balloted for, and elected as the representatives of this Institute on the General Council of the Federation :—

## COUNCIL.

*Elected Members.*

1 W. Armstrong, Jun., Esq.
2 Sir Lowthian Bell, Bart., D.C.L., F.R.S.
3 M. Walton Brown, Esq.
4 W. Cochrane, Esq.
5 J. Daglish, Esq.
6 T. Douglas, Esq.
7 G. B. Forster, Esq., F.G.S.
8 G. C. Greenwell, Esq., F.G.S.
9 G. May, Esq.
10 J. Marley, Esq.
11 J. B. Simpson, Esq., F.G.S.
12 A. L. Steavenson, Esq.
13 J. Willis, Esq.
14 Lindsay Wood, Esq.

*Co-optated Members.*

1 W. Armstrong, Sen., Esq., F.G.S.
2 T. J. Bewick, Esq., F.G.S.
3 R. F. Boyd, Esq.
4 D. Dale, Esq.

The accompanying Finance Report shows the position of the Institute to be perfectly and progressively sound, and that notwithstanding the fact that a considerable expenditure has been necessitated by the conversion of one of the basement rooms into an excellent apartment for the general meetings of the Institute, and of another into a stock-room, in which all the publications have been arranged in a most elaborate and convenient manner, under the superintendence of Mr. F. Gosman.

The following comparative table shows the present state of membership :—

| | 1886-87. | 1887-88. | 1888-89. | 1889-90. |
|---|---|---|---|---|
| Honorary Members ... | 20 | 21 | 27 | 26 |
| Original Members ... | 439 | 412 | 387 | 600 |
| Ordinary Members ... | 41 | 42 | 42 | |
| Associate Members ... | 156 | 168 | 174 | |
| Students ... ... | 69 | 63 | 48 | 43 |
| Collieries ... ... | 15 | 15 | 16 | 18 |

There have been 25 resignations and 8 deaths, and 16 names have been removed from the list of members for non-payment of contributions. On the other hand 42 new names have been added to the lists.

Of the committees appointed to make special investigations, that on Fan Ventilation has been fully employed in carrying out an extensive series of experiments.

The Flameless Explosives Committee having now obtained valuable facilities for the carrying out of their observations, are about to commence actual experimental work.

The Committee appointed to confer with the College of Science as to a course of mining engineering have concluded their labours, and a very complete syllabus of the kind of instruction proposed to be given in the Durham College of Science for students in mining engineering, drawn up by Principal Garnett and the other professors of the College, and recommended by the Committee, has been approved of by the Council, on the understanding that they are strongly in favour of the curriculum being framed for not more than two years. The syllabus will be printed in the Transactions.*

A committee has been formed to investigate and report on coal-cutting machines.

The papers read during the past year are the following :—

The Danger attending the use of Light Mineral Oils for Lubricating Air-compressing Machinery. By Mr. John Morison.

Charles Pit—Flaggy Creek Pit Heading : Description of the Survey. By Mr. Jas. Hunter.

Notes on the Variations in the Faulting of Coal observed in the action of the same series of Faults in three Seams at Redheugh Colliery. By Mr. T. O. Robson.

Outbursts of Gas in Metalliferous Mines. By Mr. B. H. Brough.

Coal Mining at Warora, Central Provinces, East India. By Mr. Charles Z. Bunning.

The Gold-fields of the Valley of De Kaap, Transvaal, South Africa. By Mr. J. M. Liddell.

* See page xiii.

The Pieler Spirit-Lamp as a Fire-Damp Indicator. By Mr. M. Walton Brown.

Notes of Reports on the Winning of the High Main Coal, at Gosforth Colliery, on the South Side of the Ninety-Fathom Dyke; and of the Winning of that Seam by Pits sunk on the South Side of the Dyke, and Drifting through that Dyke to Win the Coal on the North Side, with extracts from the various Reports relating thereto. By Mr. T. W. Embleton.

An Account of Experiments on the Resistance to Air Currents in Mines. By Mr. T. L. Elwen.

The Economical Working of Steam Boilers at Collieries. By Messrs. W. Armstrong, jun., and W. J. Bird.

# Finance Report.

THE Income for the year 1888-89 amounted to £1,811 1s. 7d., showing an increase over that of the preceding year of £224 14s. 2d., but the second dividend due from the Institute and Coal Trade Chambers Company, Limited, and unpaid at the time of making up the last Annual Accounts, was then shown as an Asset, and is now included in the above amount.

The Expenditure was £1,518 0s. 1d., being £293 1s. 0d. below the income, and £249 1s. 8d. less than last year. There is, however, an outstanding account due to the publishers of the Transactions, amounting to about £63.

The total receipts for subscriptions and arrears were £1,450 2s. 0d., £142 15s. 0d. more than last year, and the arrears of subscriptions now amount to £533 7s. 0d., as against £642 12s. 0d. last year.

JOHN B. SIMPSON.
G. B. FORSTER.

July 20th, 1889.

# TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

DR.

| | | £ s. d. | £ s. d. |
|---|---|---|---|
| July 17, 1888. | | | |
| To Balance at Bankers ... ... ... ... ... | (12) | 199 17 7 | |
| To Balance in Cashier's hands... ... ... ... | (64) | 29 0 1 | |
| | | | 228 17 8 |
| July 16, 1889. | | | |
| To Dividend of 5½ per cent. on 134 Shares, of £20 each, in the Institute and Coal Trade Chambers Company, Limited, for the Year ending December, 1888 ... ... ... | (357) | 147 8 0 | |
| To Dividend of 4¾ per cent. for the Half-year ending June, 1889 ... ... ... ... ... | (357) | 100 10 0 | |
| | | 247 18 0 | |
| To Interest on investments with the River Tyne Commissioners ... ... ... ... ... | (130) | 75 10 9 | |
| | | | 323 8 9 |
| To Rent of College Class Rooms ... ... ... | (181) | | 12 2 3 |
| To Subscriptions for 1888-89, as follows :— | | | |
| 305 Original Members ... ... ... ... | | 640 10 0 | |
| 30 Ordinary Members ... ... ... ... | | 90 6 0 | |
| 136 Associate Members .. ... ... | | 285 12 0 | |
| 32 Students ... ... ... ... | | 33 12 0 | |
| 2 New Ordinary Members ... ... ... | | 6 6 0 | |
| 16 New Associate Members ... ... ... | | 33 12 0 | |
| 1 New Do. paid as Life Member | | 20 0 0 | |
| 7 New Students ... ... ... ... | | 7 7 0 | |
| | | 1,117 5 0 | |
| To Subscribing Collieries, viz. :— | | | |
| Ashington ... ... ... ... £2 2 0 | | | |
| Birtley Iron Company ... ... 6 6 0 | | | |
| Haswell ... ... ... ... 4 4 0 | | | |
| Hetton ... ... .. ... 10 10 0 | | | |
| Lambton ... ... ... ... 10 10 0 | | | |
| Londonderry ... ... ... 10 10 0 | | | |
| Marquess of Bute ... ... ... 10 10 0 | | | |
| North Hetton ... ... ... 6 6 0 | | | |
| Ryhope ... ... ... ... 4 4 0 | | | |
| Seghill .. ... ... ... 2 2 0 | | | |
| South Hetton and Murton ... 4 4 0 | | | |
| Stella ... ... ... ... 2 2 0 | | | |
| Throckley ... ... ... ... 2 2 0 | | | |
| Victoria Garesfield ... ... 2 2 0 | | | |
| Wearmouth... ... ... ... 4 4 0 | | | |
| Bridgewater Trustees ... ... 6 6 0 | | | |
| Hutton Henry ... ... ... 2 2 0 | | | |
| North Brancepeth ... ... ... 4 4 0 | | | |
| | | 94 10 0 | |
| | | 1,211 15 0 | |
| To Arrears ... ... ... ... ... ... | | 238 7 0 | |
| | | | 1,450 2 0 |
| To Sale of Publications per A. Reid ... ... ... | | 18 12 5 | |
| Less 10 per cent. Commission... ... ... | | 1 17 2 | |
| | | 16 15 3 | |
| To Sale of Publications, per Secretary ... ... | | 8 13 4 | |
| | | | 25 8 7 |
| | | | £2,039 19 3 |

# INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

Cr.

| July 16, 1889. | | | | | | £ | s. | d. |
|---|---|---|---|---|---|---|---|---|
| By Publishing and Stationery Accounts, viz. :— | | | | | | | | |
| | A. Reid. | | | Lambert & Co. | | | | |
| | £ | s. | d. | £ | s. | d. | | |
| Publishing Transactions ... ... | 190 | 14 | 0 | 25 | 17 | 3 | | |
| Covers for Parts, folding & stitching | 21 | 17 | 0 | 3 | 4 | 0 | | |
| Binding and Sewing Volumes .. | 11 | 2 | 11 | ..... | | | | |
| Borings and Sections... ... ... | 19 | 10 | 0 | ..... | | | | |
| Library ... ... ... ... | 13 | 0 | 3 | ..... | | | | |
| Stationery and Circulars .. ... | 49 | 0 | 4 | 36 | 11 | 10 | | |
| Postage ... .. ... ... | 18 | 17 | 8 | 4 | 14 | 4 | | |
| | 324 | 2 | 2 | 70 | 7 | 5 | | |
| | | | | | | | 394 | 9 | 7 |
| By Books, &c., for Library, in addition to above (136) | | | | | | 29 | 7 | 3 | | |
| By Printing and Stationery do. ... (140) | | | | | | 9 | 14 | 1 | | |
| By Abstracts of Foreign Papers ... ... ... (103) | | | | | | 15 | 18 | 9 | | |
| By Secretary's Incidental Expenses and Postages (122) | | | | | | 96 | 1 | 9 | | |
| By Sundry Accounts and Payments ... ... (327) | | | | | | 36 | 9 | 7 | | |
| By Travelling Expenses ... ... ... ... (351) | | | | | | 12 | 3 | 0 | | |
| By Secretary's Salary ... ... ... ... (189) | | | | | | 200 | 0 | 0 | | |
| By Cashier's Salary ... ... ... ... ... (189) | | | | | | 75 | 0 | 0 | | |
| By Clerk's Wages ... ... ... ... ... (209) | | | | | | 103 | 1 | 2 | | |
| By Reporter's Salary ... ... ... ... (267) | | | | | | 12 | 12 | 0 | | |
| By Rent ... ... ... ... ... .. (181) | | | | | | 87 | 13 | 6 | | |
| By Rates and Taxes ... ... ... ... ... (156) | | | | | | 19 | 3 | 2 | | |
| By Fire Insurance ... ... ... ... (125) | | | | | | 9 | 4 | 11 | | |
| By Furnishing and Repairs... ... ... ... (114) | | | | | | 151 | 16 | 11 | | |
| By Coals, Gas, and Water ... ... ... ... (109) | | | | | | 12 | 6 | 4 | | |
| | | | | | | | 870 | 12 | 5 |
| | | | | | | | 1,265 | 2 | 0 |
| By Expenses of Meeting in Scotland ... ... (364) | | | | | | 27 | 0 | 0 | | |
| By Expenses of Delegate, British Association, Bath (364) | | | | | | 15 | 0 | 0 | | |
| By Expenses of Earth Tremors Committee ... (368) | | | | | | 0 | 18 | 6 | | |
| By Expenses of Fan Committee ... ... ... (371) | | | | | | 99 | 13 | 11 | | |
| By Expenses of Ryhope Air-receiver ... ... (372) | | | | | | 19 | 2 | 6 | | |
| By Wood Memorial Hall—cleaning and furnishing Lecture Rooms (lately occupied by College), repairs to roof, &c. ... ... ... ... (465) | | | | | | 68 | 15 | 2 | | |
| By Preparation of Index to Vols. 1-37 ... ... (467) | | | | | | 22 | 8 | 0 | | |
| | | | | | | | 252 | 18 | 1 |
| | | | | | | | 1,518 | 0 | 1 |
| By Balance at Bankers ... ... ... ... (16) | | | | | | 481 | 19 | 2 | | |
| By Balance in Cashier's hands ... ... ... (76) | | | | | | 40 | 0 | 0 | | |
| | | | | | | | 521 | 19 | 2 |
| | | | | | | | £2,039 | 19 | 3 |

Audited and found correct,

JOHN G. BENSON,

Chartered Accountant.

Newcastle-on-Tyne,

31st July, 1889.

## Dr. THE TREASURER IN ACCOUNT

| | | | £ | s. | d. |
|---|---|---|---|---|---|
| To 387 Original Members, as per List, 1888-89, 10 of whom are Life Members. | | | | | |
| 377 @ £2 2s. ... ... ... ... ... ... ... ... | | | 791 | 14 | 0 |
| To 42 Ordinary Members, as per List, 1888-89, 3 of whom are Life Members. | | | | | |
| 39 (35 @ £3 3s.; 4 @ £2 2s.) ... ... ... ... ... ... | | | 118 | 13 | 0 |
| To 174 Associate Members, as per List, 1888-89, 9 of whom are Life Members. | | | | | |
| 165 @ £2 2s. ... ... ... ... .. ... ... ... | | | 346 | 10 | 0 |
| To 48 Students, as per List, 1888-89. | | | | | |
| 48 @ £1 1s. ... ... ... ... .. .. ... ... | | | 50 | 8 | 0 |
| To 4 New Ordinary Members, @ £3 3s. ... ... ... ... | | | 12 | 12 | 0 |
| To 23 New Associate Members, 1 paid as Life Member ... ... ... ... .. ... | | | 20 | 0 | 0 |
| 22 @ £2 2s. ... ... ... .. .. ... .. ... | | | 46 | 4 | 0 |
| To 8 New Students, @ £1 1s. ... ... .. ... ... ... | | | 8 | 8 | 0 |
| To Subscribing Collieries, &c. ... ... ... ... ... ... | | | 94 | 10 | 0 |
| | | | 1,488 | 19 | 0 |
| To Arrears, as per Balance Sheet, 1887-88 ... ... | £642 | 12 0 | | | |
| *Less* struck out as irrecoverable ... ... ... | 128 | 2 0 | | | |
| | | | 514 | 10 | 0 |
| | | | £2,003 | 9 | 0 |

WITH SUBSCRIPTIONS, 1888-89. CR.

| | | | | PAID. £ s. d. | UNPAID. £ s. d. |
|---|---|---|---|---|---|
| By 305 | Original Members | paid | @ £2 2s. ... | 640 10 0 | ..... |
| By 52 | Do. | unpaid | ,, ... | ..... | 109 4 0 |
| By 5 | Do. | dead | ,, ... | ..... | 10 10 0 |
| By 6 | Do. | resigned | ,, ... | ..... | 12 12 0 |
| By 9 | Do. | struck off | ,, ... | ..... | 18 18 0 |
| 377 | | | | | |
| By 26 | Ordinary Members | paid | @ £3 3s. ... | 81 18 0 | ..... |
| By 4 | Do. | paid | @ £2 2s. ... | 8 8 0 | ..... |
| By 7 | Do. | unpaid | @ £3 3s. ... | ..... | 22 1 0 |
| By 1 | Do. | resigned | @ £3 3s. ... | ..... | 3 3 0 |
| By 1 | Do. | struck off | @ £3 3s. ... | ..... | 3 3 0 |
| 39 | | | | | |
| By 136 | Associate Members | paid | @ £2 2s. .. | 285 12 0 | ..... |
| By 21 | Do. | unpaid | ,, ... | ..... | 44 2 0 |
| By 3 | Do. | resigned | ,, ... | ..... | 6 6 0 |
| By 5 | Do. | struck off | ,, ... | ..... | 10 10 0 |
| 165 | | | | | |
| By 32 | Students | paid | @ £1 1s. ... ... ... | 33 12 0 | ..... |
| By 13 | Do. | unpaid | ,, ... ... ... | ..... | 13 13 0 |
| By 2 | Do. | resigned | ,, .. ... ... | ..... | 2 2 0 |
| By 1 | Do. | struck off | ,, ... ... ... | ..... | 1 1 0 |
| 48 | | | | | |
| By 2 | New Ordinary Members | paid | @ £3 3s. ... | 6 6 0 | ..... |
| By 2 | Do. | unpaid | ,, ... | ..... | 6 6 0 |
| 4 | | | | | |
| By 16 | New Associate Members | paid | @ £2 2s. ... | 33 12 0 | ..... |
| By 6 | Do. | unpaid | ,, ... | ..... | 12 12 0 |
| 22 | | | | | |
| 1 | Do. | paid as Life Member | | 20 0 0 | ..... |
| By 7 | New Students | paid | @ £1 1s. ... ... | 7 7 0 | ..... |
| By 1 | Do. | unpaid | ,, ... ... | ..... | 1 1 0 |
| 8 | | | | | |
| By Subscribing Collieries, &c., paid ... ... ... | | | | 94 10 0 | ..... |
| | | | | 1,211 15 0 | 277 4 0 |
| By Arrears ... ... ... ... ... ... ... | | | | 238 7 0 | 276 3 0 |
| | | | | 1,450 2 0 | 553 7 0 |
| | | | | | 1,450 2 0 |

Audited and found correct,

JOHN G. BENSON, CHARTERED ACCOUNTANT.

Newcastle-on-Tyne,
31st July, 1889.

£2,003 9 0

DR. GENERAL STATEMENT, JULY 16TH, 1889. CR.

| Liabilities. | £ | s. | d. |
|---|---|---|---|
| Promised Donation to the British Association ... ... ... ... ... ... | 105 | 0 | 0 |
| Capital ... ... ... ... ... ... | 11,924 | 11 | 2 |
| | £12,029 | 11 | 2 |

Audited and found correct.
(Share Certificates and Bonds produced.)

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-on-Tyne,
31st July, 1889.

| Assets. | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Balance of Account at Bankers ... ... ... ... | 481 | 19 | 2 | | | |
| Do. in Cashier's hands ... ... ... ... | 40 | 0 | 0 | | | |
| | | | | 521 | 19 | 2 |
| 134 Shares of £20 each in the Institute and Coal Trade Chambers Company, Limited ... ... ... | | | | 2,680 | 0 | 0 |
| Invested with River Tyne Commissioners ... ... | | | | 2,000 | 0 | 0 |
| Arrears of Subscriptions ... ... ... ... ... | | | | 553 | 7 | 0 |
| Value of 576 Bound Volumes of Transactions, @ 11s. 6d. | 331 | 4 | 0 | | | |
| Value of 4,523 Sewn Volumes of Transactions, @ 9s. ... | 2,035 | 7 | 0 | | | |
| Value of 1,873 Unbound Parts of Transactions, @ 2s. | 187 | 6 | 0 | | | |
| Value of 79 Copies of Mr. T. F. Brown's Map, @ 5s. ... | 19 | 15 | 0 | | | |
| Value of 376 Copies of Index, Vols 1-25, @ 3s. ... | 56 | 8 | 0 | | | |
| Value of 760 Copies of Fossil Illustrations, @ 12s. 6d. | 475 | 0 | 0 | | | |
| Value of 851 Copies of Catalogue of Fossils, @ 5s. ... | 212 | 15 | 0 | | | |
| Value of 1,500 Copies of Borings and Sinkings, Vol. I. (in Sheets) ... ... ... ... ... ... | 300 | 0 | 0 | | | |
| Value of 298 Copies of Borings and Sinkings, Vol. I. @ 5s. | 74 | 10 | 0 | | | |
| Value of 321 Copies Do. Do. Vol. II. @ 5s. | 80 | 5 | 0 | | | |
| Value of 338 Copies Do. Do. Vol. III. @ 5s. | 84 | 10 | 0 | | | |
| Value of 457 Copies Do. Do. Vol. IV. @ 5s. | 114 | 5 | 0 | | | |
| Value of Sheets of Borings and Sinkings, Vol. V., unpublished at date ... ... ... ... ... | 39 | 0 | 0 | | | |
| Value of 256 Copies of Library Catalogue, @ 5s. ... | 64 | 0 | 0 | | | |
| | | | | 4,074 | 5 | 0 |
| Value of Office Furniture and Fittings ... ... ... | 450 | 0 | 0 | | | |
| Value of Books and Maps in Library ... ... ... | 1,750 | 0 | 0 | | | |
| | | | | 2,200 | 0 | 0 |
| | | | | £12,029 | 11 | 2 |

# DURHAM COLLEGE OF SCIENCE.

## COURSE OF INSTRUCTION FOR MINING ENGINEERS.

### First Year.

Elementary Algebra and Geometry, the use of Logarithms. Trigonometry with special reference to surveying.

Laws and Principles of Dynamics. Elementary Statics.

Practical Geometry, plane and descriptive, and the Elements of Machine Drawing.

Elementary Experimental Physics, especially Heat and Electricity.

The Principles of Chemistry, outline of Inorganic Chemistry.

Practical Chemistry, including—Preparation of gases. Blow pipe analysis. Elementary qualitative analysis.

Physical and Stratigraphical Geology, Mineralogy, Geological Field Work.

More advanced students should be encouraged to attend during their first year the evening lectures on Applied Mechanics, Steam, &c. Those who have had no experience in Mining should spend two days a week during the first year in practical work in a mine.

### Second Year.

Practical Surveying.

The Elements of Co-ordinate Geometry, simple applications of the differential calculus and examples of integration.

Graphic and Analytical Statics. Hydrostatics and Pneumatics.

The Elements of Strength of Materials and Machine Design.

Moments of Inertia and elements of Rigid Dynamics. Elasticity and Strength of Materials, including Transverse Strength and Deflection of Beams and Girders, Strength of Pillars, Strength of Shafts to resist Torsion, Strength of Riveted Joints, with special reference to Boilers, Strength of Vessels to resist Fluid Pressure.

Hydraulics, including the Flow of Liquids and Gases through Pipes and Orifices, Pumps, Turbines, Natural and Mechanical Ventilation.

The Transmission of Power by Belting, Ropes, Shafting, Water, Compressed Air, and Electricity.

The Steam Engine, Indicator and Valve Diagrams, &c. Design of Boilers and Chimneys. Air required for Combustion. Grate Area and Heating Surface necessary to meet given requirements. Simple, Compound, and Triple Expansion Engines. Types of Engines best adapted for special classes of work.

The elements of Building Construction.

Electricity, the Dynamo, Electric Motors, Lamps, and other appliances. Electrical Testing.

Chemistry, special course, including:—Fuel—Phenomena of Combustion. Composition and Classification of Fuels. Solid Fuel—Wood, Charcoal. Coal—Classification of Coals, Valuation of Coal, Manufacture and Analysis of Coke. Liquid Fuel—Composition, Valuation, and general examination of Mineral Oils. Gaseous Fuel—Manufacture of Coal Gas and of Gas for heating purposes, General Principles of Gas Analysis.

Analytical examination of the Air of Mines. Nature of Gases met with in Mines.

Water—Composition of Natural Waters in relation to their use for Steam-raising purposes. Composition of Boiler Scales and the methods adopted to prevent their production.

Fire-resisting materials, Composition of Clays, &c.

General Outline of Metallurgy.

Practical Chemistry. Determination of Minerals by aid of the blow-pipe.

Principles of Quantitative Analysis.

Assay and ultimate Analysis of Coal and Coke.

Methods of Gas Analysis.

Technical Gas Analysis.

Water Analysis as far as refers to the use of Waters for Steam-raising purposes.

Metallurgy of Iron, Lead, Copper, Silver, Gold, &c.

Practical Metallurgy. General Metallurgical operations, Assaying of Ores by Dry and Wet Methods. (This section is more especially adapted to those Students who intend to qualify as Engineers in Metalliferous Mines.)

Mining—

1.—Discussion of facts connected with the deposits of useful Minerals, including Costeaning and Boring.

2.—Tools used in Mining, including Explosives.

3.—Sinking of Shafts, Driving of Drifts, and Surveying.

4.—Systems of Working.

5.—Draining, Hauling, and Winding.

6.—The Law of Mines.

7.—Washing and Dressing of Materials.

8.—Lighting and Ventilation.

Students who can devote three Sessions to the College Course will be able to obtain a knowledge of the more advanced parts of Mathematics and Mechanics and of Chemical Analysis.

Mining Students should attend the classes in Mathematics, Mechanics, Physics, Inorganic Chemistry, Geology, and Mechanical Drawing, in addition to the Lectures of the Professor of Mining, in order to obtain instruction in all the subjects of the preceding syllabus.

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For the carrying out of this scheme, besides the staff and appliances at present possessed by the College, the following will be necessary :—

A Teacher of Metallurgy and a Metallurgical Laboratory with wind and muffle furnaces ; a large room for the display of Models connected with Mining, and for the lecture appliances of the Professor of Mining ; a Laboratory provided with Machines for Testing the Strength of Materials and the efficiency of Lubricants, and an Experimental Steam Engine as described in the scheme of Instruction for Mechanical Engineers ; a Collection of Models, Diagrams, and Apparatus illustrative of the lectures on Mining and Mechanical Engineering.

It is hoped that a Professor of Engineering will shortly be appointed in connection with the Scheme of Instruction for Mechanical and Marine Engineers.* In the meanwhile Machine Drawing and Design, the principles of Applied Mechanics, Steam, &c., are taught by the existing staff.

If a Testing Room for Safety Lamps, Anemometers, Electrical Appliances, &c., is located at the College it will prove a most valuable adjunct to the facilities now offered to the Students.

* Mr. R. L. Wrightson, M.A., has been appointed in this capacity, and will commence his duties September, 1891.

# Patrons.

His Grace the DUKE OF NORTHUMBERLAND.
His Grace the DUKE OF CLEVELAND.
The Most Noble the MARQUIS OF LONDONDERRY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF RAVENSWORTH.
The Right Honourable the EARL OF WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.
WENTWORTH B. BEAUMONT, Esq., M.P.

# Honorary Members.

| * Honorary Members during term of office only. | Elected. Mem. | Hon. |
|---|---|---|
| The Right Honourable the EARL OF RAVENSWORTH, Ravensworth Castle, Gateshead-on-Tyne ... ... ... ... ... | | 1877 |
| * J. B. ATKINSON, Esq., Inspector of Mines, Glasgow... ... ... | | 1888 |
| * W. N. ATKINSON, Esq., Inspector of Mines, Newcastle, Staffordshire | | 1888 |
| * BEATTIE-SCOTT, W., Inspector of Mines, Great Barr, near Birmingham ... ... .. ... ... .. ... ... | | 1888 |
| * Prof. P. PHILLIPS BEDSON, D.Sc. (Lond.), F.C.S., Durham College of Science, Newcastle-on-Tyne ... ... ... ... | | 1883 |
| * THOMAS BELL, Esq., Inspector of Mines, Durham ... ... ... | | |
| M. DE BOUREUILLE, Commandeur de la Légion d'Honneur, Conseiller d'état, Inspecteur Général des Mines, Paris ... ... | | 1853 |
| * Prof. G. S. BRADY, M.D., LL.D., F.R.S., F.L.S., Durham College of Science, Newcastle-on-Tyne... ... ... ... ... ... | | 1875 |
| Dr. BRASSERT, Berghauptmann, Bonn-am-Rhein, Prussia ... ... | | 1883 |
| JOSEPH DICKINSON, Esq., F.G.S., Inspector of Mines, Manchester | | 1853 |
| * C. LE NEVE FOSTER, Esq., D.Sc., F.G.S., Inspector of Mines, Llandudno ... ... ... ... ... ... ... ... | | 1888 |
| * Prof. WILLIAM GARNETT, M.A., D.C.L., Principal of the Durham College of Science, Newcastle-on-Tyne ... ... ... | | 1884 |
| * HENRY HALL, Esq., Inspector of Mines, Rainhill, Prescott ... | | 1876 |
| * Prof. A. S. HERSCHEL, M.A., D.C.L., F.R.S., F.R.A.S., Durham College of Science, Newcastle-on-Tyne ... ... ... ... | | 1872 |
| The Very Rev. Dr. LAKE, Dean of Durham ... ... ... ... | | 1872 |
| * Prof. G. A. LEBOUR, M.A., F.G.S., Durham College of Science, Newcastle-on-Tyne ... ... ... ... ... ... ... | 1873 | 1879 |
| J. A. LONGRIDGE, Esq., Grêve d'Ayetté, Jersey ... ... ... | | 1886 |
| * J. S. MARTIN, Esq., Inspector of Mines, Clifton ... ... ... | | 1888 |

| | Elected. Mem. | Hon. |
|---|---|---|
| * A. E. PINCHING, Esq., Inspector of Mines, Stoke, Devonport ... | | 1888 |
| * JOSEPH T. ROBSON, Esq., Inspector of Mines, Swansea ... ... | | 1888 |
| * J. M. RONALDSON, Esq., Inspector of Mines, 44, Athole Gardens, Glasgow... ... ... ... ... ... ... ... ... ... | | 1888 |
| Sir WARINGTON W. SMYTH, M.A., F.R.S., F G.S., F.R.G.S., 28, Jermyn Street, London ... ... ... ... ... ... | | 1869 |
| * A. H. STOKES, Esq., Inspector of Mines, Greenhill, Derby ... ... | | 1888 |
| M. E. VUILLEMIN, Mines d'Aniche, Nord, France ... ... ... | | 1878 |
| * FRANK N. WARDELL, Esq., F.G.S., Inspector of Mines, Wath-on-Dearne, near Rotherham .. ... ... ... ... ... | 1864 | 1868 |
| * JAMES WILLIS, Esq., Inspector of Mines, 14, Portland Terrace, Newcastle-on-Tyne ... ... ... ... ... ... ... | 1857 | 1871 |

# OFFICERS, 1889-90.

## President.

JOHN MARLEY, Esq., Thornfield, Darlington.

## Vice-Presidents.

T. J. BEWICK, Esq., M.I.C.E., F.G.S., Suffolk House, Laurence Pountney Hill, London, E.C.
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A. L. STEAVENSON, Esq., Durham.

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HENRY ARMSTRONG, Esq., Chester-le-Street.
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R. F. BOYD, Esq., Houghton-le-Spring, Fence Houses, Co. Durham.
M. WALTON BROWN, Esq., 3, Summerhill Terrace, Newcastle.
V. W. CORBETT, Esq., Chilton Moor, Fence Houses.
S. C. CRONE, Esq., Killingworth Hall, Newcastle-on-Tyne.
W. F. HALL, Esq., Haswell Colliery, Haswell, *via* Sunderland.
W. H. HEDLEY, Esq., Medomsley, Newcastle.
T. HEPPELL, Esq., Leafield House, Birtley, Chester-le-Street.
H. LAWRENCE, Esq., Grange Iron Works, Durham.
M. W. PARRINGTON, Esq., Wearmouth Colliery, Sunderland.
Hon. C. A. PARSONS, Elvaston Hall, Ryton-on-Tyne.
R. ROBINSON, Esq., Howlish Hall, near Bishop Auckland.
T. H. M. STRATTON, Esq., Cramlington House, Northumberland.
J. G. WEEKS, Esq., Bedlington, R.S.O., Northumberland.
R. L. WEEKS, Esq., Willington, Co. Durham.
W. O. WOOD, Esq., South Hetton, Fence Houses.

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*Ex-Officio.* — Past-Presidents:

Sir GEORGE ELLIOT, Bart., M.P., D.C.L., Houghton Hall, Fence Houses.
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G. B. FORSTER, Esq., M.A., F.G.S., Lesbury, R.S.O., Northumberland.
JOHN DAGLISH, Esq., Marsden, South Shields.
Sir LOWTHIAN BELL, Bart., D.C.L., F.R.S., Rounton Grange, Northallerton.

Retiring Vice-Presidents:

CUTHBERT BERKLEY, Esq., Marley Hill, Whickham, R.S.O., Co. Durham.
THOMAS DOUGLAS, Esq., Pease's West Colliery, Darlington.
JAMES WILLIS, Esq., 14, Portland Terrace, Newcastle.

## Secretary.

Prof. G. A. LEBOUR, M.A., F.G.S., Neville Hall, Newcastle-on-Tyne.

# List of Members.

## 1889-90

## Members.

Marked * are Life Members.

| | | Elected. |
|---|---|---|
| 1 | Ackroyd, Wm., Morley Main Collieries, Morley, near Leeds .. | Feb. 7, 1880 |
| 2 | Agniel, S., Mines de Vicoigne (Nord), Nœux (P. de C.), France ... | April 23, 1887 |
| 3 | Aitkin, Henry, Falkirk, N.B. ... ... .. ... ... | Mar. 2, 1865 |
| 4 | Allan, John F., La Carolina, Provincia de St. Luis, Argentine Republic ... ... ... ... ... ... ... ... | Feb. 10, 1883 |
| 5 | Allison, J. J. C., Hedley Hill Colliery, Waterhouses, Durham... | Feb. 13, 1886 |
| 6 | Anderson, C. W., Belvedere, Harrogate ... ... ... ... | Aug. 21, 1852 |
| 7 | Anderson, R. S., Elswick Colliery, Newcastle-on-Tyne ... ... | June 9, 1883 |
| 8 | Andrews, Hugh, Swarland Hall, Felton, Northumberland ... | Oct. 5, 1872 |
| 9 | Archer, T., Dunston Engine Works, Gateshead ... .. ... | July 2, 1872 |
| 10 | Armstrong, Lord, C.B., LL.D., F.R.S., D.C.L., Cragside, Rothbury (Past-President, *Member of Council)* ... ... | May 3, 1866 |
| 11 | Armstrong, Hy., Pelaw House, Chester-le-Street (*Mem. of Council*) | April 14, 1883 |
| 12 | Armstrong, Wm., F.G.S., Pelaw House, Chester-le-Street ... | Aug. 21, 1852 |
| 13 | Armstrong, W., Jun., Wingate, Co. Durham *(Mem. of Council)* | April 7, 1867 |
| 14 | Armstrong, W. L., Newton Lane Colliery, Victoria Coal and Coke Co., Limited, near Wakefield ... ... ... ... | Mar. 3, 1864 |
| 15 | Arnold, T., Mineral Surveyor, Castle Hill, Greenfields, Llanelly | Oct. 2, 1880 |
| 16 | Asquith, T. W., Harperley, Lintz Green, Newcastle-on-Tyne ... | Feb. 2, 1867 |
| 17 | Atkinson, A. A., New Brancepeth Colliery, near Durham ... | Aug. 3, 1878 |
| 18 | Atkinson, Fred., Maryport ... ... ... ... ... ... | Feb. 14, 1874 |
| 19 | Atkinson, J. B., 10, Foremount Terrace, Glasgow ... ... | Mar. 5, 1870 |
| 20 | Atkinson, W. N., Newcastle, Staffordshire ... ... ... | June 6, 1868 |
| 21 | Aubrey, R. C., Wigan Coal and Iron Co., Ltd., Standish, near Wigan | Feb. 5, 1870 |
| 22 | Austine, John, Cadzow Coal Co., Glasgow ... ... .. | Nov. 4, 1876 |
| 23 | Aynsley, Wm., Chilton Colliery, Ferry Hill ... ... ... | Mar. 3, 1873 |
| 24 | Ayton, Henry, Cowpen Colliery, Blyth, Northumberland ... | Mar. 6, 1875 |
| | | |
| 25 | Bailes, E. T., Wingate, Ferryhill ... ... ... ... ... | June 7, 1879 |
| 26 | Bailes, T., Jesmond Gardens, Newcastle ... ... ... ... | Oct. 7, 1858 |
| 27 | Bailey, Samuel, 30, Waterloo Street, Birmingham ... ... | June 2, 1859 |
| 28 | Bain, R. Donald, 85, Pembroke Road, Clifton, Bristol ... ... | Mar. 3, 1873 |
| 29 | Bainbridge, E., Nunnery Colliery Offices, Sheffield ... .. | Dec. 3, 1863 |
| 30 | Ball, Alfred F., 14, Landsdowne Terrace, Gosforth ... ... | Dec. 11, 1886 |
| 31 | Banks, Thomas, 60, King Street, Manchester ... ... ... | Aug. 4, 1877 |
| 32 | Barrett, C. R., New Seaham, Sunderland ... ... ... | Nov. 7, 1874 |
| 33 | Bartholomew, C., Castle Hill House, Ealing, London, W. ... | Aug. 5, 1853 |
| 34 | *Bartholomew, C. W., Blakesley Hall, near Towcester .. ... | Dec. 4, 1875 |
| 35 | Bates, Matthew ... ... ... ... ... ... ... | Mar. 3, 1874 |

ELECTED.

36 BATES, W. J., Winlaton, Blaydon-on-Tyne... ... ... ... Mar. 3, 1874
37 BATEY, JOHN, Newbury Collieries, Coleford, Bath... ... ... Dec, 5, 1868
38 BAUMGARTNER, W. O., Houghton-le-Spring, Fence Houses ... Sept. 6, 1879
39 BEANLANDS, ARTHUR, M.A., Palace Green, Durham ... ... Mar. 7, 1867
40 BELL, SIR LOWTHIAN, Bart., D.C.L., F.R.S., F.C.S., Rounton Grange, Northallerton (PAST-PRESIDENT, *Mem. of Council)* July 6, 1854
41 BELL, C. E., Park House, Durham ... ... ... ... ... Dec. 3, 1870
42 BELL, GEO. FRED., 4, St. Thomas' Square, Newcastle-on-Tyne ... Sept. 6, 1879
43 BENNETT, ALFRED H., Dean Lane Collieries, Bedminster, Bristol April 10, 1886
44 BENSON, J. G., Accountant, 12, Grey Street, Newcastle-on-Tyne... Nov. 7, 1874
45 BENSON, T. W., 11, Newgate Street, Newcastle *(Mem. of Council)* Aug. 2, 1866
46 BERKLEY, C., Marley Hill, Whickham, R.S.O., Co. Durham (RETIRING VICE-PRESIDENT, *Member of Council*) ... ... Aug. 21, 1852
47 BERKLEY, FREDERICK, Murton Colliery, near Sunderland ... Dec. 11, 1882
48 BERKLEY, R. W., Marley Hill, Whickham, R.S.O., Co. Durham ... Feb. 14, 1874
49 BEWICK, T. B., Hebburn, Newcastle-on-Tyne ... ... ... Mar. 7, 1874
50 BEWICK, T. J., M.I.C.E., F.G.S., Suffolk House, Laurence Pountney Hill, near London (VICE-PRESIDENT) ... ... April 5, 1860
51 BIGLAND, J., Henknowle, Bishop Auckland ... .. ... June 4, 1857
52 BINNS, G. J., F.G.S., M.G.S.A., and Lecturer on Geology at the Otago University, Government Inspector of Mines, Dunedin, New Zealand ... ... ... ... ... .. Aug. 7, 1886
53 BIRAM, B., Peaseley Cross Collieries, St. Helen's, Lancashire ... 1856
54 BIRD, W. J., Wingate, Co. Durham ... ... ... ... ... Nov. 6, 1875
55 BISHOP, JAMES, Manager, Grey Valley Coal Co., Brunnerton, Greymouth, New Zealand ... ... ... ... ... April 13, 1889
56 BLACK, W., Hedworth Villa, South Shields ... ... ... April 2, 1870
57 BLACKBURN, WM. STEVENSON, Astley House, Woodlesford, nr. Leeds Dec. 10, 1887
58 BLACKETT, W. C., Jun., Acorn Close, Sacriston, Durham ... Nov. 4, 1876
59 BLAGBURN, CHARLES, 150, Leadenhall Street, London, E.C. ... April 13, 1889
60 BLAKELEY, A. B., Soothill Wood Colliery Co., Ltd., near Batley Feb. 15, 1879
61 BOLTON, H. H., Newchurch Collieries, near Manchester ... ... Dec. 5, 1868
62 BOOTH, R. L., Ashington Colliery, near Morpeth ... ... ... 1864
63 BOUCHER, A. S., P.O. Box, 53, Krugersdorf, South African Republic ... ... ... ... ... ... ... ... Aug. 4, 1883
64 BOYD, R. F., Houghton-le-Spring, Fence Houses, Co. Durham (*Member of Council*) ... ... ... ... ... ... Nov. 6, 1869
65 BOYD, WM., North House, Longbenton, Newcastle-on-Tyne ... Feb. 2, 1867
66 BRAMWELL, HUGH, Clifton Coll., Great Clifton, near Workington Oct. 4, 1879
67 BRECKON, J. R., 41, Fawcett Street, Sunderland ... ... ... Sept. 3, 1864
68 BRETTELL, T., Mine Agent, Dudley, Worcestershire .. ... Nov. 3, 1866
69 BROJA, RICHARD, Kœniglicher Oberbergrath, 35, Friédrich Strasse, Halle, a/S. ... ... ... ... ... ... ... ... Nov. 6, 1880
70 BROUGH, BENNETT H., A.R.S.M., F.G.S., 5, Robert Street, Adelphi, London, W.C. ... ... ... ... ... ... Dec. 10, 1887
71 BROUGH, THOMAS, New Seaham Colliery, Sunderland ... ... Feb. 1, 1873
72 BROWN, M. WALTON; 3, Summerhill Terrace, Newcastle-on-Tyne (*Member of Council*)... ... ... ... ... ... Oct. 7, 1871
73 BROWN, ROBERT M., Norwood Colliery, *via* Darlington ... ... April 10, 1886
74 BROWN, THOMAS, Manager, Westport Coal Co., Coalbrookdale Colliery, Westport, New Zealand ... ... ... ... April 13, 1889
75 BROWN, THOS. FORSTER, F.G.S., Guildhall Chambers, Cardiff ... 1861

ELECTED.

76 BROWNE, SIR BENJAMIN C., M.I.C.E., Westacres, Benwell, Newcastle-on-Tyne... ... ... ... ... ... ... Oct. 1, 1870
77 BRUCE, JOHN, Port Mulgrave, Hinderwell, R.S.O., Yorkshire ... Feb. 14, 1874
78 BRYHAM, WILLIAM, Rosebridge Colliery, Wigan ... ... ... Aug. 1, 1861
79 BRYHAM, W., Jun., Douglas Bank Collieries, Wigan ... ... Aug. 3, 1865
80 BULMAN, H. F., Byer Moor, Burnopfield, near Newcastle-on-Tyne May 2, 1874
81 BUNNING, C. Z., F.G.S., c/o The Borax Co., Limited, 2, Macri Khan, Constantinople ... ... ... ... ... ... Dec. 6, 1873
82*BURLS, HERBERT T., Assoc. R.S.M., F.G.S., M.E., Box 76 Barberton, Transvaal, South Africa ... ... .. ... Feb. 9, 1889
83*BURNS, DAVID, C.E., F.G.S., Canal Bank, Carlisle ... ... May 5, 1877
84 BURROWS, J. S., Yew Tree House, Atherton, near Manchester ... Oct. 11, 1873

85 CABRERA, FIDEL, c/o H. Kendal and Son, 12, Great Winchester Street, London ... ... .. ... ... ... ... Oct. 6, 1877
86*CANDLER, T. E., F.G.S., Millwood, Cape Town ... ... ... May 1, 1875
87 CHAMBERS, A. M., Thorncliffe Iron Works, near Sheffield ... Mar. 6, 1869
88 CHAPMAN, ALFRED CRAWHALL, 29, St. Nicholas' Buildings, Newcastle-on-Tyne... ... ... ... ... ... ... Oct. 13, 1888
89 CHARLTON, W. A. (of Tangyes Limited), 8, Richmond Terrace, Gateshead ... .. ... ... ... ... ... ... Nov. 6, 1880
90 CHEESMAN, I. T., Throckley Colliery, Newcastle-on-Tyne ... Feb. 1, 1873
91 CHEESMAN, W. T., Wire Rope Manufacturer, Hartlepool ... Feb. 5, 1876
92 CHICKEN, LANCELOT W., Boldon Colliery, Co. Durham ... ... June 8, 1889
93 CHILDE, HENRY S., Mining Engineer, Wakefield ... ... ... Feb. 12, 1887
94 CLARK, C. F., Garswood Coal and Iron Co., Limited, near Wigan Aug. 2, 1866
95 CLARK, R. B., Springwell Colliery, Gateshead ... ... ... May 3, 1873
96 CLARKE, WILLIAM, Victoria Engine Works, Gateshead . . ... Dec. 7, 1867
97 CLOUGH, JAMES, Willow Bridge, Choppington, Morpeth ... ... April 5, 1873
98 COCHRANE, B., Aldin Grange, Durham ... ... ... ... Dec. 6, 1866
99 COCHRANE, C., Green Royde, Pedmore, near Stourbridge ... June 3, 1857
100 COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle (VICE-PRESIDENT) ... ... ... ... ... 1859
101 COCKBURN, W. C., 1, St. Nicholas' Buildings, Newcastle-on-Tyne Oct. 8, 1887
102 COCKSON, CHARLES, Ince Coal and Cannel Co., Ince, Wigan ... April 22, 1882
103 COLE, ROBERT HEATH, Endon, Stoke-upon-Trent ... ... ... Feb. 5, 1876
104 COLLIS, W. B., Swinford House, Stourbridge, Worcestershire ... June 6, 1861
105 COOK, J. Jun., Washington Iron Works, Gateshead ... ... May 8, 1869
106 CORBETT, V. W., Chilton Moor, Fence Houses (*Member of Council*) Sept. 3, 1870
107 CORBITT, M., Wire Rope Manufacturer, Teams, Gateshead ... Dec. 4, 1875
108 COULSON, F., 10, Victoria Terrace, Durham... ... ... ... Aug. 1, 1868
109 COULSON, W., No. 1, Pimlico, Durham ... ... ... ... Oct. 1, 1852
110 COULTHARD, FRANCIS, M.E., Arica Villa, Fox Houses, Whitehaven June 8, 1889
111 COX, JOHN H., 10, St. George's Square, Sunderland ... ... Feb. 6, 1875
112*COXE, E. B., Drifton, Jeddo, P.O. Luzerne Co., Penns., U.S. ... Feb. 1, 1873
113 CRAWSHAY, E., Gateshead-on-Tyne .. ... ... ... ... Dec. 4, 1869
114 CRAWSHAY, G., Gateshead on-Tyne ... ... ... ... ... Dec. 4, 1869
115 CRIGHTON, JOHN, 2, Clarence Buildings, Booth Street, Manchester Oct. 8, 1887
116 CRONE, E. W., Killingworth Hall, near Newcastle-on-Tyne ... Mar. 5, 1870
117 CRONE, F. E., Seaton Burn Colliery, Newcastle-on-Tyne... ... Sept. 2, 1876
118 CRONE, J. R., Tudhoe House, *via* Spennymoor ... ... ... Feb. 1, 1868
119 CRONE, S. C., Killingworth Hall, Newcastle (*Member of Council*) ... 1853

| | | Elected. |
|---|---|---|
| 120 | Cross, John, 77, King Street, Manchester ... ... ... ... | June 5, 1869 |
| 121 | Cross, W. Assheton, Messrs. R. & W. Hawthorn, Newcastle-on-Tyne | April 12, 1884 |
| 122 | Croudace, C. J., Bettisfield Colliery Co., Ltd., Bagillt, N. Wales | Nov. 2, 1872 |
| 123 | Croudace, John, West House, Haltwhistle ... ... ... | June 7, 1873 |
| 124 | Croudace, Thomas, Lambton Lodge, New South Wales ... ... | 1862 |
| 125 | Curry, W. Thos., Chelvey, Backwell, Somerset ... ... ... | Sept. 4, 1880 |
| 126 | Dacres, Thomas, Dearham Colliery, *via* Carlisle ... ... ... | May 4, 1878 |
| 127 | Daglish, John, F.G.S., Marsden, South Shields (Past-President, *Member of Council*)... ... ... ... ... ... ... | Aug. 21, 1852 |
| 128 | Daglish, W. S., Solicitor, Newcastle-on-Tyne ... .. ... | July 2, 1872 |
| 129 | Dakers, W. R., Croxdale Colliery, Durham ... ... ... | Oct. 14, 1882 |
| 130 | Dale, David, West Lodge, Darlington ... ... ... ... | Feb. 5, 1870 |
| 131 | D'Andrimont, T., Liége, Belgium ... ... ... ... ... | Sept. 3, 1870 |
| 132 | Daniel, W., Steam Plough Works, Leeds ... ... ... ... | June 4, 1870 |
| 133 | Darling, Fenwick, South Durham Colliery, Darlington... ... | Nov. 6, 1875 |
| 134 | Darlington, James, Black Park Colliery, Ruabon, North Wales | Nov. 7, 1874 |
| 135 | Davey, Hy., C.E., 3, Princes Street, Westminster, London, S.W. | Oct. 11, 1873 |
| 136 | Davies, Lt.-Col. Jasper G. S., R.E., Marton, Middlesbrough ... | Aug. 3, 1889 |
| 137 | Davies, John, Hartley House, Coundon, Bishop Auckland ... | April 10, 1886 |
| 138 | Davis, Kenneth McRae, M.E., Dudley Coll., Northumberland | April 13, 1889 |
| 139 | Dees, J. Gibson, Floraville, Whitehaven ... ... ... ... | Oct. 13, 1883 |
| 140 | Dees, R. R., Solicitor, Newcastle-on-Tyne ... ... ... .. | Oct. 7, 1871 |
| 141 | Denniston, Robert B., Stuart Street, Dunedin, New Zealand ... | Dec. 11, 1886 |
| 142 | Dixon, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea ... | Nov. 2, 1872 |
| 143* | Dixon, James S., 97, Bath Street, Glasgow... ... ... ... | Aug. 3, 1878 |
| 144 | Dixon, Nich., Dudley Colliery, Dudley, Northumberland ... | Sept. 1, 1877 |
| 145 | Dixon, R., Wire Rope Manufacturer, Teams, Gateshead... ... | June 5, 1875 |
| 146 | Dodd, B., Bearpark Colliery, near Durham... .. ... ... | May 3, 1866 |
| 147 | Dodd, M., Lemington, Scotswood-on-Tyne ... ... ... ... | Dec. 4, 1875 |
| 148 | Donkin, W., Warora Coll., Wardha Coal State Railway, C.P., India | Sept. 2, 1876 |
| 149 | Douglas, A. S., Stanley Colliery, near Crook, *via* Darlington ... | June 1, 1878 |
| 150 | Douglas, C. P., Parliament Street, Consett, Co. Durham ... | Mar. 6, 1869 |
| 151 | Douglas, John, Jun., Seghill Colliery, Dudley, Northumberland... | April 22, 1882 |
| 152 | Douglas, M. H., Marsden Colliery, South Shields ... ... | Aug. 2, 1879 |
| 153 | Douglas, T., Pease's West Collieries, Darlington (Retiring Vice-President, *Member of Council*) ... ... ... ... | Aug. 21, 1852 |
| 154 | Dowdeswell, H., Butterknowle Colliery, *via* Darlington .. | April 5, 1873 |
| 155 | Doyle, Patrick, C.E., F.M.S., F.L.S., M.R.A.S., F.G.S., M.S.I., Bengal E.I.R., Chord Line, Sitarampur, India ... ... | Mar. 1, 1879 |
| 156 | Dunn, A. F., Poynton, Stockport, Cheshire ... ... ... | June 2, 1877 |
| 157 | Durnford, H. St. John, Swaithe Colliery, near Barnsley ... | June 2, 1877 |
| 158 | Dyson, George, Middlesbrough .. ... ... ... ... | June 2, 1866 |
| 159 | Edge, J. H., Coalport Wire Rope and Chain Works, Shifnal, Salop | Sept. 7, 1878 |
| 160 | Elliot, Sir George, Bart., M.P., D.C.L., Houghton Hall, Fence Houses (Past-President, *Member of Council*)... ... | Aug. 21, 1852 |
| 161 | Ellis, W. R., F.G.S., Wigan .. ... ... ... ... ... | June 1, 1878 |
| 162 | Elsdon, Robert, The Highlands, Burnt Ash Hill, Lee, Kent | Nov. 4, 1876 |
| 163 | Elwen, Thomas Lee, Littleburn Colliery, near Durham ... ... | Oct. 13, 1888 |
| 164 | Embleton, T. W., The Cedars, Methley, Leeds ... ... ... | Sept. 6, 1855 |
| 165 | Embleton, T. W., Jun., The Cedars, Methley, Leeds ... ... | Sept. 2, 1865 |

| | | Elected. |
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| 166 | Eminson, J. B., Londonderry Offices, Seaham Harbour ... ... | Mar. 2, 1872 |
| 167 | Everard, J. B., M.E., 6, Millstone Lane, Leicester ... ... | Mar. 6, 1869 |
| 168 | Fairley, James, Craghead and Holmside Coll., Chester-le-Street | Aug. 7, 1880 |
| 169 | Farmer, A., Seaton Carew, near West Hartlepool ... ... | Mar. 2, 1872 |
| 170 | Farrow, Joseph, Brotton Mines, Brotton, R.S.O. ... ... | Feb. 11, 1882 |
| 171 | Favell, T. M., F.G.S., Etruria Iron Works, nr. Stoke-on-Trent | April 5, 1873 |
| 172 | Fenwick, Barnabas, 84, Osborne Road, Newcastle-on-Tyne ... | Aug. 2, 1866 |
| 173 | Ferens, Frederick J., Silksworth Colliery, Sunderland .. ... | Dec. 4, 1880 |
| 174 | Ferens, Robinson, Oswald Hall, near Durham ... ... ... | April 7, 1877 |
| 175 | Ferguson, D., c/o Mrs. Ferguson, 124, New City, Glasgow ... | Dec. 8, 1883 |
| 176 | Fisher, Ed. R., Nant Glas, Cross Hands, near Llanelly, S. Wales... | Aug. 2, 1884 |
| 177 | Fleming, C. E., Black, Hawthorn, and Co., Gateshead-on-Tyne... | April 13, 1889 |
| 178 | Fletcher, H., Ladyshore Coll., Little Lever, Bolton, Lancashire | Aug. 3, 1865 |
| 179 | Fletcher, Jas., Manager, Co-operative Collieries, Wallsend, near Newcastle, New South Wales ... .. ... ... | Sept. 11, 1875 |
| 180 | Fletcher, John, Rock House, Ulverstone ... ... ... ... | July 2, 1872 |
| 181 | Fletcher, Lancelot, Brigham Hill, Carlisle ... ... ... | April 14, 1888 |
| 182 | Foggin, W., North Biddick Coll., Washington Station, Co. Durham | Mar. 6, 1875 |
| 183 | Forrest, B. J., Villa Maria, Province of Cordoba, Argentine Republic ... ... ... ... ... ... ... ... | April 12, 1884 |
| 184 | Forrest, J. C., Witley Coal Co., Limited, Halesowen, Birmingham | April 12, 1884 |
| 185 | Forster, G. B., M.A., F.G.S., Lesbury, R.S.O., Northumberland (Past-President, *Member of Council)* ... ... | Nov. 5, 1852 |
| 186 | Forster, J. R., Water Company's Office, Newcastle-on-Tyne ... | July 2, 1872 |
| 187 | Forster, J. T., Burnhope Colliery, near Lanchester, Co. Durham | Aug 1, 1868 |
| 188 | Forster, R., Shincliffe Hall, near Durham... ... ... ... | Sept. 5, 1868 |
| 189 | Forster, Thomas E., Lesbury, R.S.O., Northumberland... ... | Oct. 7, 1876 |
| 190 | Foster, George, Osmondthorpe Colliery, near Leeds ... ... | Mar. 7, 1874 |
| 191 | France, Francis, St. Helens' Coll. Co., Ltd., St. Helens, Lancashire | Sept. 1, 1877 |
| 192 | Fryar, Mark, Denby Colliery, Derby ... ... .. ... | Oct. 7, 1876 |
| 193 | Galloway, T. Lindsay, M.A., Argyll Colliery, Campbeltown, N.B. | Sept. 2, 1876 |
| 194 | Galloway, Wm., Mining Engineer, Cardiff ... ... .. | April 23, 1887 |
| 195 | Geddes, George H., 142, Princes Street, Edinburgh ... ... | Oct. 1, 1881 |
| 196 | Gerrard, James, 19, King Street, Wigan ... ... ... ... | Mar. 3, 1873 |
| 197 | Gerrard, John, Westgate, Wakefield ... ... ... ... | Mar. 5, 1870 |
| 198 | Gilchrist, J. R., Durham Main Colliery, Durham ... ... | Feb. 3, 1877 |
| 199 | Gillett, F. C., 20, Midland Road, Derby ... ... ... ... | July 4, 1861 |
| 200 | Gilroy, G., Woodlands, Parbold, near Wigan ... ... ... | Aug. 7, 1856 |
| 201 | Gilroy, S. B., Mining Engineer, Nuneaton... ... ... .. | Sept. 5, 1868 |
| 202 | Gjers, John, Southfield Villas, Middlesbrough ... ... ... | June 7, 1873 |
| 203 | Goddard, F. R., Accountant, Newcastle-on-Tyne... ... ... | Nov. 7, 1874 |
| 204 | Grace, E. N., Dhadka, Asansol, Bengal, India ... ... ... | Feb. 1, 1868 |
| 205 | Greaves, J. O., St. John's, Wakefield ... ... ... ... | Aug. 7, 1862 |
| 206 | Green, J. T., Mining Engineer, Ty Celyn, Abercarne, Newport, Mon. | Dec. 3, 1870 |
| 207 | Greener, Henry, South Pontop Colliery, Annfield Plain ... | Dec. 11, 1882 |
| 208 | Greener, John, General Manager, Vale Colliery, New Glasgow, Pictou, Nova Scotia ... ... ... ... .. ... | Feb. 6, 1875 |
| 209 | Greener, T. Y., Hucknall Torkard Collieries, near Nottingham ... | July 2, 1872 |
| 210 | Greenwell, G. C., F.G.S., Elm Tree Lodge, Duffield, Derby (Past-President, *Member of Council*) ... ... ... ... | Aug. 21, 1852 |

ELECTED.

211 GREENWELL, G. C., Jun., Poynton, near Stockport ... ... Mar. 6, 1869
212 GRESLEY, W. S., F.G.S., Assoc. Inst. C.E., Reed House, Erie, Pa., U.S.A. ... ... ... ... ... ... ... ... Oct. 5, 1887
213 GREY, C. G., Ballycourcy, Enniscorthy, County Wexford ... May 4, 1872
214 GRIFFITH, N. R., Wrexham ... ... ... ... ... ... 1866
215 GRIMSHAW, E. J., 23, Hardshaw Street, St. Helens, Lancashire... Sept. 5, 1868
216 GUTHRIE, JAMES K., M.E., Eltringham Colliery, Prudhoe, R.S.O. Aug. 3, 1889

217 HADDOCK, W. T., Jun., Ryhope Colliery, Sunderland ... ... Oct. 7, 1876
218 HAGGIE, D. H., Wearmouth Patent Rope Works, Sunderland ... Mar. 4, 1876
219 HAGGIE, PETER SINCLAIR, Gateshead-on-Tyne ... ... ... April 14, 1883
220*HAGUE, ERNEST, Castle Dyke, Sheffield ... ... ... ... Mar. 2, 1872
221 HAINES, J. RICHARD, Adderley Green Colliery, near Longton ... Nov. 7, 1874
222 HALL, M., Lofthouse Station Collieries, near Wakefield ... ... Sept. 5, 1868
223 HALL, M. S., 8, Victoria Street, Bishop Auckland ... ... Feb. 14, 1874
224 HALL, TOM, Haswell Colliery, Haswell, *via* Sunderland ... ... June 8, 1889
225 HALL, WM., Murton Colliery, *via* Sunderland ... ... ... Dec. 4, 1875
226 HALL, WILLIAM F., Haswell Colliery, Haswell, *via* Sunderland *(Member of Council)* ... ... ... .. ... ... May 13, 1858
227 HALLAS, G. H., Wigan and Whiston Coal Co., Limited, Prescot ... Oct. 7, 1876
228 HALSE, EDWARD, 15, Clarendon Road, Notting Hill, London, W.... June 13, 1885
229 HAMILTON, E., Rig Wood, Saltburn-by-the-Sea ... ... ... Nov. 1, 1873
230 HANN, EDMUND, Aberaman, Aberdare ... ... ... ... Sept. 5, 1868
231 HARBOTTLE, W. H., Orrell Coal and Cannel Co., near Wigan ... Dec. 4, 1875
232 HARGREAVES, WILLIAM, Rothwell Haigh, Leeds ... ... ... Sept. 5, 1868
233 HARLE, RICHARD, Browney Colliery, Durham ... ... ... April 7, 1877
234 HARLE, WILLIAM, Pagebank Colliery, near Durham ... ... Oct. 7, 1876
235 HARRIS, W. S., Kibblesworth, Gateshead-on-Tyne ... ... Feb. 14, 1874
236 HARRISON, R., Eastwood, near Nottingham ... ... ... 1861
237 HARRISON, W. B., Brownhills Collieries, near Walsall ... .. April 6, 1867
238 HAY, J., Jun., Widdrington Colliery, Acklington... ... ... Sept. 4, 1869
239 HEAD, JEREMIAH, Coatham, Redcar ... ... ... ... ... Aug. 3, 1889
240 HEDLEY, J. J., Consett Collieries, Leadgate, Co. Durham ... April 6, 1872
241 HEDLEY, J. L., Flooker's Brook, Chester ... ... ... ... Feb. 5, 1870
242 HEDLEY, SEPT. H., Bank Chambers, Wakefield ... ... ... Feb. 15, 1879
243 HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne *(Member of Council)* ... ... ... ... ... ... 1864
244 HENDERSON, H., Pelton Colliery, Chester-le-Street ... ... Feb. 14, 1874
245 HENDY, J. C. B., Stanton Iron Co.'s Coll., Pleasley, nr. Mansfield, Notts Sept. 2, 1876
246 HENSHAW, A. MAYON, M.E., Talk-o'-th'-Hill Coll., Stoke-on-Trent June 8, 1889
247 HEPPELL, T., Leafield House, Birtley, Chester-le-Street *(Member of Council)* ... ... ... ... ... ... .. ... Aug. 6, 1863
248 HESLOP, C., Upleatham and Lingdale Mines, Upleatham, R.S.O., Yorkshire ... ... ... ... ... ... ... ... Feb. 1, 1868
249 HESLOP, GRAINGER, Whitwell Coal Company, Sunderland ... Oct. 5, 1872
250 HESLOP, SEPTIMUS, Belrooi Coll., Sitirampur, E.I.R., Bengal, India Dec. 4, 1880
251 HESLOP, THOMAS, Storey Lodge Colliery, Cockfield, *via* Darlington Oct. 2, 1880
252 HETHERINGTON, D., Greenfield Terrace, Newcastle-on-Tyne ... 1859
253*HEWITT, G. C., Coal Pit Heath Colliery, near Bristol ... ... June 3, 1871
254 HEWLETT, A., Haseley Manor, Warwick ... ... ... ... Mar. 7, 1861
255 HIGSON, JACOB, J. & P. Higson, 18, Booth Street, Manchester ... 1861
256 HILL, WILLIAM, Carterthorne Colliery Offices, Witton-le-Wear ... June 9, 1883

| | | Elected. |
|---|---|---|
| 257* | Hilton, J., 72, Hawkshead Street, Southport ... ... ... | Dec. 7, 1867 |
| 258 | Hilton, T. W., F.G.S., Wigan Coal and Iron Co., Limited, Wigan | Aug. 3, 1865 |
| 259 | Hodgson, John, M.E., Edomsley Colliery, Newcastle-on-Tyne ... | Oct. 12, 1889 |
| 260 | Holliday, Martin F., Langley Grove, Durham ... ... ... | May 1, 1875 |
| 261 | Hollis, Henry Wm., North Lodge, Darlington ... ... ... | June 8, 1889 |
| 262 | Holme, James, Engineer's Department, Canadian Pacific Railway, Winnipeg, Canada ... ... ... ... ... ... .. | June 12, 1886 |
| 263 | Holmes, C., Grange Hill, near Bishop Auckland ... ... ... | April 11, 1874 |
| 264 | Homer, Charles J., Mining Engineer, Stoke-on-Trent ... ... | Aug. 3, 1865 |
| 265 | Hood, A., 6, Bute Crescent, Cardiff ... .. ... ... ... | April 18, 1861 |
| 266 | Hope, George, Success House, Fence Houses ... ... ... | Feb. 3, 1877 |
| 267 | Hopkins, Edward, M.E., Weardale Place, St. John's Chapel ... | Oct. 12, 1889 |
| 268 | Hornsby, H., Old Cornforth, near Ferryhill ... ... ... | Aug. 1, 1874 |
| 269 | Horsley, W., Whitehill Point, Percy Main, Newcastle-on-Tyne | Mar. 5, 1857 |
| 270 | Hoskold, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c., Inspector General of Mines of the Argentine Republic, and Director of the National Department of Mines and Geology, Casilla, Correos, 900, Buenos Ayres ... ... ... | April 1, 1871 |
| 271 | Howard, W. F., 13, Cavendish Street, Chesterfield .. ... | Aug. 1, 1861 |
| 272 | Humble, John, West Pelton, Chester-le-Street ... ... ... | Mar. 4, 1871 |
| 273 | Hunter, J., Kirk Merrington, *via* Ferry Hill ... ... ... | Mar. 6, 1869 |
| 274 | Hurst, T. G., F G.S., Osborne Road, Newcastle-on-Tyne ... | Aug. 21, 1852 |
| 275 | Irvine, Joseph R., Hendon Ropery, Sunderland ... ... ... | Dec. 10, 1887 |
| 276 | Jackson, C. G., Hartford House, Werneth, Oldham ... ... | June 4, 1870 |
| 277 | Jackson, W. G., Hicklam House, Aberford, near Leeds... ... | June 7, 1873 |
| 278 | Jacques, J. Routledge, Box 21, Heidelberg, Transvaal, S.A.R. | June 8, 1889 |
| 279 | Jarratt, J., Houghton Main Colliery, near Barnsley ... ... | Nov. 2, 1867 |
| 280 | Jeffcock, T. W., 18, Bank Street, Sheffield ... ... ... | Sept. 4, 1869 |
| 281 | Jenkins, W., M.E., Ocean Collieries, Treorky, Glamorgan ... | Dec. 6, 1862 |
| 282 | Jenkins, Wm., Consett Iron Works, Consett, Durham ... ... | May 2, 1874 |
| 283 | Jepson, H., 10, Crossgate, Durham ... ... ... ... ... | July 2, 1872 |
| 284* | Jobling, Thos. E., Croft Villa, Blyth, Northumberland... ... | Oct. 7, 1876 |
| 285 | Johnson, H., Jun., Mining Offices, Trindle Road, Dudley, South Staffordshire ... ... ... ... ... ... | Feb. 10, 1883 |
| 286 | Johnson, J., Carlton Main Colliery, Barnsley ... ... ... | Mar. 7, 1874 |
| 287 | Johnson, R. S., Sherburn Hall, Durham ... ... ... ... | Aug. 21, 1852 |
| 288 | Johnson, W., Abram Colliery, Wigan ... ... ... ... | Feb. 14, 1874 |
| 289 | Johnson, Wm., Radcliffe Colliery, Acklington, Northumberland | Dec. 9, 1882 |
| 290 | Joicey, J. G., Forth Banks West Factory, Newcastle-on-Tyne ... | April 10, 1869 |
| 291 | Joicey, W. J., Urpeth Lodge, Chester-le-Street ... ... ... | Mar. 6, 1869 |
| 292 | Kayll, A. C., Gosforth, Newcastle-on-Tyne ... ... ... | Oct. 7, 1876 |
| 293 | Kellett, William, Wigan ... ... ... ... ... ... | June 1, 1878 |
| 294 | Kendall, John D., Roper Street, Whitehaven ... ... ... | Oct. 3, 1874 |
| 295 | Kirkby, J. W., Kirkland, Leven, Fife ... ... ... ... | Feb. 1, 1873 |
| 296 | Kirkup, Philip, Cornsay Colliery Office, Esh, near Durham ... | Mar. 2, 1878 |
| 297 | Kirton, Hugh, Waldridge Colliery, Chester-le-Street ... ... | April 7, 1877 |
| 298 | Knowles, A., Swinton Old Hall, Manchester ... ... ... | Dec. 5, 1856 |
| 299 | Knowles, I., Wigan ... ... ... ... ... ... ... | Oct. 13, 1883 |
| 300 | Knowles, John, Westwood, Pendlebury, Manchester ... ... | Dec. 5, 1856 |
| 301* | Knowles, Robert, Arncliffe, Cheetham Hill, Manchester ... | April 10, 1886 |

| | | Elected. |
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| 302 | Lamb, R., Bowthorn Colliery, Cleator Moor, near Whitehaven... | Sept. 2, 1865 |
| 303 | Lamb, R. O., The Lawn, Ryton-on-Tyne ... ... ... ... | Aug. 2, 1866 |
| 304 | Lamb, Richard W., 29, Great Cumberland Place, London, W.... | Nov. 2, 1872 |
| 305 | Lancaster, John, Anfield House, Leamington ... ... ... | Mar. 2, 1865 |
| 306 | Lancaster, John, Auchinheath, Southfield and Fence Collieries, Lesmahagow ... ... ... ... ... ... ... | Sept. 7, 1878 |
| 307 | Landale, A., Comely Park Place, Dunfermline ... ... ... | Dec. 2, 1858 |
| 308* | Laporte, H., M.E., Aciéries de France, Aubin, Aveyron, France | May 5, 1877 |
| 309 | Laverick, John Wales, Tow Law Colliery Office, Tow Law, R.S.O., Co. Durham ... ... ... ... ... ... | Dec. 11, 1882 |
| 310 | Laverick, Robt., West Rainton, Fence Houses ... ... ... | Sept. 2, 1876 |
| 311 | Lawrence, H., Grange Iron Works, Durham (*Member of Council*) | Aug. 1, 1868 |
| 312 | Laws, H., Grainger Street W., Newcastle-on-Tyne ... ... | Feb. 6, 1869 |
| 313 | Laws, W. G., Town Hall, Newcastle-on-Tyne ... ... ... | Oct. 2, 1880 |
| 314 | Leach, C. C., Seghill Colliery, Northumberland ... ... ... | Mar. 7, 1874 |
| 315 | Lebour, G. A., M.A., F.G.S., Durham College of Science, Newcastle (Secretary)... .. ... ... ... ... ... | Feb. 1, 1873 |
| 316 | Lee, John F., Castle Eden Colliery, Co. Durham ... ... ... | June 13, 1885 |
| 317 | Lee, William, Felling Colliery, Newcastle-on-Tyne ... ... | Dec. 10, 1887 |
| 318 | Lever, Ellis, Bowdon, Cheshire ... ... ... ... ... | 1861 |
| 319 | Lewis, Sir William Thomas, Mardy, Aberdare ... ... ... | 1864 |
| 320 | Liddell, G. H., Somerset House, Whitehaven ... ... ... | Sept. 4, 1869 |
| 321 | Liddell, J. M., 3, Victoria Villas, Newcastle-on-Tyne ... ... | Mar. 6, 1875 |
| 322 | Linsley, R., Cramlington Colliery, Northumberland ... ... | July 2, 1872 |
| 323 | Linsley, S. W., Whitburn Colliery, South Shields .. ... | Sept. 4, 1869 |
| 324 | Lishman, T., Jun., Hetton Colliery, Fence Houses .. ... | Nov. 5, 1870 |
| 325 | Lishman, Wm., Holly House, Witton-le-Wear ... ... ... | 1857 |
| 326 | Lishman, Wm., Bunker Hill, Fence Houses (Vice-President) ... | Mar. 7, 1861 |
| 327 | Lisle, J. ... ... ... ... ... ... ... ... ... | July 2, 1872 |
| 328 | Liveing, E. H., 52, Queen Anne St., Cavendish Sq., London, W. | Sept. 1, 1877 |
| 329 | Livesey, C., Bradford Colliery, near Manchester ... ... ... | Aug. 3, 1865 |
| 330 | Livesey, T., Bradford Colliery, near Manchester ... ... .. | Nov. 7, 1874 |
| 331 | Llewellin, David Morgan, F.G.S., Glanwern Offices, Pontypool | May 14, 1881 |
| 332 | Llewelyn, L., Abersychan House, Abersychan ... ... ... | May 4, 1872 |
| 333 | Logan, William, Langley Park Colliery, Durham ... ... | Sept. 7, 1867 |
| 334 | Longbotham, J., Barrow Collieries, Barnsley, Yorkshire... ... | May 2, 1868 |
| 335 | Lupton, A., F.G.S., 6, De Grey Road, Leeds ... ... ... | Nov. 6, 1869 |
| 336 | MacCabe, H. O., Russell Vale, Wollongong, New South Wales... | Sept. 7, 1878 |
| 337 | Mackinlay, T. B., West Pelton Colliery, Chester-le-Street ... | Nov. 1, 1879 |
| 338 | Maddison, Thos. R., Dirtcar House, near Wakefield ... ... | Mar. 3, 1877 |
| 339 | Makepeace, H. R., Powell Duffryn Coal Co., Limited, Aberaman, Aberdare ... ... ... ... ... ... ... ... | Mar. 3, 1877 |
| 340 | Maling, C. T., Ellison Place, Newcastle-on-Tyne ... ... ... | Oct. 5, 1872 |
| 341 | Mammatt, J. E., C.E., St. Andrew's Chambers, Leeds ... ... | 1864 |
| 342 | Markham, G. E., Howlish Offices, Bishop Auckland ... ... | Dec. 4, 1875 |
| 343 | Marley, John, Thornfield, Darlington (President) ... ... | Aug. 21, 1852 |
| 344 | Marley, J. W., 7, Bondgate, Darlington ... ... ... ... | Aug. 1, 1868 |
| 345 | Marshall, F. C., Messrs. R. & W. Hawthorn, St. Peter's, Newcastle | Aug. 2, 1866 |
| 346 | Marston, W. B., Leeswood Vale Oil Works, Mold ... ... | Oct. 3, 1868 |
| 347 | Marten, E. B., C.E., Pedmore, near Stourbridge ... ... ... | July 2, 1872 |
| 348 | Martin, Tom Pattinson, Allhallows Colliery, Mealsgate, Carlisle | Feb. 15, 1879 |

| | | Elected. |
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| 349 | Matthews, J., Messrs. R. and W. Hawthorn, Newcastle-on-Tyne | April 11, 1885 |
| 350 | Matthews, R. F., Harehope Hall, Alnwick... ... ... ... | Mar. 5, 1857 |
| 351 | Maughan, J. A., Manager of the Government Central Provinces' Collieries, Umaria, *via* Katni, India, C.P. .. ... ... | Nov. 7, 1863 |
| 352 | May, G., Harton Coll. Offices, nr. South Shields (Vice-President) | Mar. 6, 1862 |
| 353 | McCarthy, E. T., A.R.S.M., c/o Col. Pigott, Higbury, Eastbourne | Oct. 8, 1887 |
| 354 | McCreath, J., 95, Bath Street, Glasgow ... ... ... .. | Mar. 5, 1870 |
| 355 | McCulloch, David, Beech Grove, Kilmarnock, N.B. ... .. | Dec. 4, 1875 |
| 356 | McLaren, B., Heddon Coal and Fire Brick Co., Wylam-on-Tyne | Dec. 10, 1883 |
| 357 | McMurtrie, J., Radstock Colliery, Bath ... ... ... ... | Nov. 7, 1863 |
| 358 | Merivale, Prof. J. H., M.A., 2, Victoria Villas, Newcastle-on-Tyne | May 5, 1877 |
| 359* | Merivale, W., The Deanery, Ely ... ... ... ... ... | Mar. 5, 1881 |
| 360 | Meysey-Thompson, A. H., Sun Foundry, Leeds ... ... ... | April 13, 1889 |
| 361 | Miller, D. S., Cheadle, Staffordshire ... ... ... ... | Nov. 7, 1874 |
| 362 | Mills, M. H., Kirklye Hall, Alfreton ... ... ... ... | Feb. 4, 1871 |
| 363 | Mitchell, Chas., Jesmond, Newcastle-on-Tyne ... ... ... | April 11, 1874 |
| 364 | Mitchell, Joseph, Mining Offices, Eldon Street, Barnsley ... | Feb. 14, 1874 |
| 365 | Mitchinson, R., Jun., Pontop Colliery, Lintz Green Station, Co. Durham ... ... ... ... ... ... ... ... | Feb. 4, 1865 |
| 366 | Mitton, A. D., Hetton Colliery, Fence Houses ... ... ... | June 9, 1883 |
| 367 | Monkhouse, Jos., Gilcrux, Cockermouth ... ... ... ... | June 4, 1863 |
| 368 | Moor, Wm., Jun., Hetton Colliery, Fence Houses... ... ... | July 2, 1872 |
| 369 | Moore, R. W., Somerset House, Whitehaven ... ... ... | Nov. 5, 1870 |
| 370 | Moore, William, Loftus Mines, Loftus-in-Cleveland, R.S.O. ... | Nov. 19, 1881 |
| 371 | Moreing, C. A., Suffolk House, Laurence Pountney Hill, London, E.C. ... ... ... ... ... ... ... ... | Nov. 7, 1874 |
| 372 | Morison, John, Newbattle Collieries, Dalkeith, N.B. ... ... | Dec. 4, 1880 |
| 373 | Morris, W., Waldridge Colliery, Chester-le-Street ... ... | 1858 |
| 374* | Morton, H. J., 2, Westbourne Villas, South Cliff, Scarborough ... | Dec. 5, 1856 |
| 375 | Morton, H. T., Lambton, Fence Houses ... ... ... ... | Aug. 21, 1852 |
| 376 | Mulholland, M. L., 74, Weardale Street, Mount Pleasant, Spennymoor, Co. Durham ... ... ... ... ... | Dec. 11, 1886 |
| 377 | Mundle, Arthur, St. Nicholas' Chambers, Newcastle-on-Tyne... | June 5, 1875 |
| 378 | Mundle, W., Redesdale Mines, Bellingham ... ... ... | Aug. 2, 1873 |
| 379 | Murton, Chas. J., Delaval Benwell Colliery, Newcastle-on-Tyne | Mar. 6, 1880 |
| 380 | Musgrave, Henry, Havercroft Main Colliery, Wakefield ... | June 12, 1886 |
| 381* | Nasse, Rudolph, Oberbergrath, Saarbrücken, Prussia .. ... | 1869 |
| 382 | Nevin, John, Dunbottle House, Mirfield, Normanton ... .. | May 2, 1868 |
| 383 | Nichol, Wm., De Beers Mine, Kimberley, South Africa... ... | Oct. 9, 1886 |
| 384 | Nicholson, E., Jun., Beamish Colliery, Chester-le-Street ... | Aug. 7, 1869 |
| 385 | Nicholson, Marshall, Middleton Hall, Leeds ... ... ... | Nov. 7, 1863 |
| 386 | Noble, Captain, C.B., F.R.S., F.R.A.S., F.C.S., Jesmond, Newcastle-upon-Tyne .. ... ... ... ... ... ... | Feb. 3, 1866 |
| 387 | North, F. W., F.G.S., Rowley Hall Coll, Dudley, Staffordshire | Oct. 6, 1864 |
| 388 | Ogden, John M., Solicitor, Sunniside, Sunderland ... ... | Mar. 5, 1857 |
| 389 | Ogilvie, A. Graeme, 8, Grove End Road, St. John's Wood, London | Mar. 3, 1877 |
| 390 | Ornsby, R. E., Seaton Delaval Colliery, Northumberland ... | Mar. 6, 1875 |
| 391 | Palmer, Sir Chas. Mark, Bart., M.P., Quay, Newcastle-on-Tyne | Nov. 5, 1852 |
| 392 | Palmer, A. S., Usworth Hall, Washington Station, Co. Durham | July 2, 1872 |
| 393 | Palmer, Henry, East Howle Colliery, near Ferryhill ... ... | Nov. 2, 1878 |

| | | Elected. |
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| 394 | Pamely, C., 21, Morgan Street, Pontypridd, South Wales ... | Sept. 5, 1868 |
| 395 | Panton, F. S., Silksworth Colliery, Sunderland ... ... ... | Oct. 5, 1867 |
| 396 | Parrington, M. W., Wearmouth Colliery, Sunderland (*Member of Council*) ... ... ... ... ... ... ... ... | Dec. 1, 1864 |
| 397 | Parsons, Hon. Charles Algernon, Elvaston Hall, Ryton-on-Tyne (*Member of Council*) ... ... ... ... ... | June 12, 1886 |
| 398 | Peace, M. W., Wigan, Lancashire .. ... ... ... ... | July 2, 1872 |
| 399 | Peake, C. E., Eskell Chambers, Nottingham ... ... ... | Nov. 3, 1877 |
| 400 | Peake, R. C., Stoke Lodge, Bletchley, Bucks .. ... ... | Feb. 7, 1880 |
| 401 | Pearce, F. H., Bowling Iron Works, Bradford ... ... ... | Oct. 1, 1857 |
| 402 | Pease, Sir J. W., Bart., M.P., Hutton Hall, Guisbrough, Yorkshire | Mar. 5, 1857 |
| 403 | Peel, John, Leasingthorne Colliery, Bishop Auckland ... ... | Mar. 3, 1877 |
| 404 | Peile, William, Cartgate, Hensingham, Whitehaven ... ... | Oct. 1, 1863 |
| 405 | Pickup, P. W., 71, Preston New Road, Blackburn ... ... | Feb. 6, 1875 |
| 406 | Plummer, John, Assistant-Inspector of Mines, Bishop Auckland | June 8, 1889 |
| 407 | Potter, Addison, C.B., Heaton Hall, Newcastle-on-Tyne ... | Mar. 6, 1869 |
| 408 | Potter, A. M., Shire Moor Colliery, Earsdon, Newcastle ... | Feb. 3, 1872 |
| 409 | Potter, C. J., Heaton Hall, Newcastle-on-Tyne ... .. .. | Oct. 3, 1874 |
| 410 | Potts, Jos., Jun., North Cliff, Roker, Sunderland ... ... | Dec. 6, 1879 |
| 411 | Prest, J. J., Kimblesworth Colliery, Chester-le-Street ... ... | May 1, 1875 |
| 412 | Prest, T., Bedlington Colliery, R.S.O., Northumberland ... | June 14, 1884 |
| 413 | Price, J. R., Standish, near Wigan ... ... ... ... ... | Aug. 7, 1869 |
| 414 | Price, John, 6, Osborne Villas, Jesmond, Newcastle-on-Tyne ... | Mar. 3, 1877 |
| 415 | Price, S. R., Cottam Colliery, Barlbro, near Chesterfield ... | Nov. 3, 1877 |
| 416 | Pringle, Edward, Choppington Colliery, Northumberland ... | Aug. 4, 1877 |
| 417 | Pringle, H. A., The Southern Coal Company of New South Wales, Limited, Wollongong, New South Wales ... ... | Dec. 4, 1880 |
| 418* | Prior, Edward G., Victoria, British Columbia ... ... ... | Feb. 7, 1880 |
| 419 | Proctor, C. P., Lightcliffe, near Halifax, Yorkshire ... ... | Oct. 7, 1876 |
| 420 | Proud, Joseph, South Hetton Colliery Offices, Sunderland ... | Oct. 14, 1882 |
| 421 | Ramsay, J. A., Sherburn and Littletown Collieries, near Durham | Mar. 6, 1869 |
| 422 | Ramsay, Wm., Tursdale, Co. Durham ... ... ... ... | Sept. 11, 1875 |
| 423 | Rathbone, Edgar P., Johannesburg, P.O. Box 563, Transvaal, South Africa ... .. ... ... ... ... ... | Mar. 7, 1878 |
| 424 | Reed, Robert, Felling Colliery, Gateshead... ... ... ... | Dec. 3, 1863 |
| 425 | Reid, Andrew, Newcastle-on-Tyne ... ... ... . ... | April 2, 1870 |
| 426 | Rhodes, C. E., Carr House, Rotherham ... ... ... ... | Aug. 4, 1883 |
| 427 | Rich, William, Minas de Rio Tinto, Provincia de Huelva, Spain | June 9, 1888 |
| 428 | Richardson, H., Backworth Colliery, Newcastle-on-Tyne ... | Mar. 2, 1865 |
| 429 | Richardson, J. W., Iron Shipbuilder, Newcastle-on-Tyne ... | Sept. 3, 1870 |
| 430 | Ridley, G., 16, Dean Street, Newcastle-on-Tyne ... ... ... | Feb. 4, 1865 |
| 431 | Ridyard, J., Bridgewater Offices, Walkden, near Bolton-le-Moors, Lancashire ... ... ... ... ... ... ... ... | Nov. 7, 1874 |
| 432 | Ritson, U. A., 6, Queen Street, Newcastle-on-Tyne ... ... | Oct. 7, 1871 |
| 433 | Roberts, Charles Warren, Manager, Llechwedd Slate Mine, Plas Wennydd, Blaenau, Festiniog, North Wales ... ... | April 13, 1889 |
| 434 | Robertson, W., M.E., 123, St. Vincent Street, Glasgow ... | Mar. 5, 1870 |
| 435 | Robinson, Frank, The Nunnery, Orrell Mount, Wigan ... ... | Sept. 2, 1876 |
| 436 | Robinson, G. C., Brereton and Hayes Coll., Rugeley, Staffordshire | Nov. 5, 1870 |
| 437 | Robinson, R., Howlish Hall, near Bishop Auckland (*Member of Council*) ... ... ... ... ... ... ... ... | Feb. 1, 1868 |

| | | Elected. |
|---|---|---|
| 438 | Robson, J. S., Butterknowle Colliery, *via* Darlington ... ... | 1853 |
| 439 | Robson, T. O., Bensham Crescent, Gateshead-on-Tyne ... ... | Sept. 11, 1875 |
| 440 | Rogerson, John, Croxdale Hall, Durham .. ... ... ... | Mar. 6, 1869 |
| 441 | Roscamp, J., Shilbottle Coll., Lesbury, R.S.O., Northumberland | Feb. 2, 1867 |
| 442 | Ross, J. A. G., Consulting Engineer, 13, Belgrave Terr., Newcastle | July 2, 1872 |
| 4 3 | Rosser, W., Mineral Surveyor, Llanelly, Carmarthenshire ... | 1856 |
| 444 | Rothwell, R. P., 27, Park Place, New York, U. S. ... ... | Mar. 5, 1870 |
| 445 | Routledge, Jos., Ryhope Colliery, Sunderland ... ... ... | Sept. 11, 1875 |
| 446 | Routledge, Wm., S. and L.C. and R. Co., Reserve Colliery, Sydney, Cape Breton .. ... ... ... ... ... | Aug. 6, 1857 |
| 447 | Routledge, W. H., The Rhyd, Tredegar, Mon., Wales ... ... | Oct. 7, 1876 |
| 448 | Russell, Robert, Coltness Iron Works, Newmains, N.B. ... | Aug. 3, 1878 |
| 449 | Rutherford, W., South Derwent Coll., Annfield Plain, Lintz Green | Oct. 3, 1874 |
| 450 | Ryder, W. J. H., Forth Street Brass Works, Newcastle-on-Tyne | Nov. 4, 1876 |
| 451 | Saint, George, Vauxhall Collieries, Ruabon, North Wales ... | April 11, 1874 |
| 452* | Saise, Walter, D.Sc. (Lond.), F.G.S., M.Inst.C.E., Manager E.I.R. Collieries, Giridi, Bengal, India... ... ... ... | Nov. 3, 1877 |
| 453 | Sawyer, A. R., Ass. R.S.M., Newcastle, Staffordshire ... ... | Dec. 6, 1873 |
| 454 | Scarth, W. T., Raby Castle, Staindrop, Darlington ... ... | April 4, 1868 |
| 455 | Scott, Andrew, Broomhill Colliery, Acklington ... ... ... | Dec. 7, 1867 |
| 456 | Scott, C. F., Grove Cottage, Leadgate, Co. Durham ... ... | April 11, 1874 |
| 457 | Scott, Walter, Cornsay Colliery, Lanchester ... ... ... | Sept. 6, 1879 |
| 458 | Scott, Wm., Brancepeth Colliery Offices, Willington, Co. Durham | Mar. 4, 1876 |
| 459 | Scoular, G., Cleator Moor, *via* Carnforth ... ... ... ... | July 2, 1872 |
| 460 | Selby, Atherton, Leigh, near Manchester ... ... .. | Oct. 13, 1883 |
| 461 | Shaw, W., Wellington Cast Steel Foundry, Middlesbrough ... | June 3, 1871 |
| 462 | Shiel, John, Framwellgate Colliery, Co. Durham ... ... | May 6, 1871 |
| 463 | Shipley, T., Woodland Colliery Office, Woodland, Butterknowle, R.S.O., Co. Durham ... ... ... ... ... ... | Aug. 2, 1884 |
| 464 | Shone, Isaac, Great George Street Chambers, Parliament Square, London, S.W. ... ... ... .. ... ... ... | 1858 |
| 465 | Shore, Wm. Martin, Manager, Kaitangata Railway and Coal Co.'s Collieries, Otago, New Zealand ... ... ... ... | April 13, 1889 |
| 466 | Shute, C. A., Westoe, South Shields ... ... ... ... | April 11, 1874 |
| 467 | Simpson, F. L. G., Mohpani Coal Mines, Gadawarra, C.P., India | Dec. 13, 1884 |
| 468 | Simpson, J., Heworth Colliery, near Gateshead-on-Tyne ... | Dec. 6, 1866 |
| 469 | Simpson, J. B., F.G.S., Hedgefield House, Blaydon-on-Tyne (Vice-President) ... ... ... ... ... ... ... | Oct. 4, 1860 |
| 470 | Simpson, R., Moor House, Ryton-on-Tyne .. ... ... ... | Aug. 21, 1852 |
| 471 | Simpson, Robt., Drummond Coll., Westville, Pictou, Nova Scotia | Dec. 4, 1875 |
| 472 | Slinn, T., 2, Choppington Street, Westmorland Road, Newcastle | July 2, 1872 |
| 473 | Smith, Eustace, Wire Rope Manufacturer & Shipbuilder, Newcastle | June 11, 1887 |
| 474* | Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell ... ... | Dec. 5, 1874 |
| 475 | Smith T. E., Phœnix Foundry, Newgate St., Newcastle-on-Tyne | Dec. 5, 1874 |
| 476 | Sopwith, A., Cannock Chase Collieries, near Walsall ... ... | Aug. 1, 1868 |
| 477 | Sopwith, Thos., 6, Great George St., Westminster, London, S.W. | Mar. 3, 1877 |
| 478 | Southern, E. O., Ashington Colliery, near Morpeth ... ... | Dec. 5, 1874 |
| 479 | Southern, R., Burleigh House, The Parade, Tredegarville, Cardiff | Aug. 3, 1865 |
| 480 | Southworth, Thos., Hindley Green Collieries, near Wigan ... | May 2, 1874 |
| 481 | Spence, R. F., Cramlington, R.S.O., Northumberland ... ... | Nov. 2, 1878 |
| 482 | Spencer, John, Westgate Road, Newcastle-on-Tyne ... ... | Sept. 4, 1869 |

ELECTED.

483 SPENCER, JOHN W., Newburn, near Newcastle-on-Tyne ... ... May 4, 1878
484 SPENCER, T., Ryton, Newcastle-on-Tyne ... ... ... ... Dec. 6, 1866
485 SPENCER, W., Southfields, Leicester .. ... ... ... ... Aug. 21, 1852
486 STANSFELD, HAROLD SINCLAIR, Flockton Manor, Wakefield ... Oct. 13, 1888
487 STEAVENSON, A. L. Durham (VICE-PRESIDENT) ... ... ... Dec. 6, 1855
488 STEPHENSON, G.R., 9, Victoria Cham., Westminster, London, S.W. Oct. 4, 1860
489 STEVENS, JAMES, M.E., 9, Fenchurch Avenue, London, E.C. ... Feb. 14, 1885
490 STOBART, F., Pensher House, Fence Houses ... ... ... Aug. 2, 1873
491 STOBART, H. T., Wearmouth Colliery, Sunderland ... ... Oct. 2, 1880
492 STOBART, W., Pepper Arden, Northallerton ... ... ... July 2, 1874
493 STOKER, ARTHUR P., Birtley, near Chester-le-Street ... ... Oct. 6, 1877
494 STOREY, THOS. E., Clough Hall Iron Works, Kidsgrove, Staffordshire Feb. 5, 1872
495 STRAKER, J. H., Stagshaw House, Corbridge-on-Tyne ... ... Oct. 3, 1876
496 STRATTON, T. H. M., Cramlington House, Northumberland *(Member of Council)* ... ... ... ... ... ... Dec. 3, 1870
497 STREATFIELD, HUGH S., The Limes, Leigham Court Road, Streatham June 8, 1889
498 SWALLOW, J., Bushblades House, Lintz Green, Newcastle-on-Tyne May 2, 1874
499 SWALLOW, R. T., Wardley Hall, Newcastle-on-Tyne ... ... 1862
500 SWAN, H. F., Shipbuilder, Newcastle-on-Tyne ... ... ... Sept. 2, 1871
501 SWAN, J. G., Upsall Hall, near Middlesbrough ... ... .. Sept. 2, 1871
502 SWANN, C. G., Sec., General Mining Association Ltd., Blomfield House, London Wall, and New Broad Street, London, E.C. Aug. 7, 1875

503 TATE, SIMON, Trimdon Grange Colliery, Co. Durham ... ... Sept. 11, 1875
504 TAYLOR, HUGH, King Street, Quay, Newcastle-on-Tyne ... ... Sept. 5, 1856
505 TAYLOR, T., Quay, Newcastle-on-Tyne ... ... ... ... July 2, 1872
506 TAYLOR-SMITH, THOMAS, Heathdale, Gosforth, Newcastle-on-Tyne Aug. 2, 1866
507 TELFORD, W. H., Hedley Hope Collieries, Tow Law, R.S.O., Co. Durham ... ... .. .. ... ... ... ... Oct. 3, 1874
508 THOMPSON, CHARLES LACY, Milton Hall, Carlisle ... ... ... Feb. 10, 1883
509 THOMPSON, R., Jun., 19, The Crescent, Gateshead ... ... Sept. 7, 1867
510 THOMPSON, W., M.E., Ross Buildings, Charters Towers, North Queensland, Australia ... ... ... ... ... ... Aug. 4, 1888
511 THOMSON, JOHN, Eston Mines, by Middlesbrough ... ... ... April 7, 1877
512 THOMSON, JOS. F., Manvers Main Colliery, Rotherham ... ... Feb. 6, 1875
513 TINN, J., C.E., Ashton Iron Rolling Mills, Bedminster, Bristol... Sept. 7, 1867
514 TODD, JOHN T., Bedford Lodge, Bishop Auckland... ... ... Nov. 4, 1876
515 TOPLEY, WILLIAM, F.R.S., F.G.S., of H.M. Geological Survey, 28, Jermyn Street, London, S.W. ... ... .. ... Oct. 12, 1889
516*TYERS, JOHN E., Lowland Villa, 19, Wellington, New Swindon, Wiltshire ... ... ... ... ... ... ... ... Dec. 10, 1887
517 TYZACK, D., F.G.S., c/o Mr. Donnison, 71, Westgate Road, Newcastle-on-Tyne... ... ... ... ... ... .. Feb. 14, 1874
518 TYZACK, WILFRED, South Medomsley Coll., Lintz Green, Newcastle Oct. 7, 1876

519 VARTY, THOMAS, Skelton Park Mines, Skelton, R.S.O., Cleveland Feb. 12, 1887
520 VASEY, THOS. W., Littleburn Colliery, near Durham ... ... Oct. 13, 1888
521 VITANOFF, GEO. N., Sophia, Bulgaria ... ... ... ... April 22, 1882
522 VIVIAN, JOHN, Diamond Boring Company, Whitehaven ... ... Mar. 3, 1877

523 WADHAM, E., C. and M.E., Millwood, Dalton-in-Furness ... Dec. 7, 1867
524 WAIN, WM. HOLT, Podmore Hall Coll., Newcastle-under-Lyne Feb. 12, 1887

| | | Elected. |
|---|---|---|
| 525 | Walker, J. S., Pagefield Iron Works, Wigan, Lancashire ... | Dec. 4, 1869 |
| 526 | Walker, Sydney Ferris, 196, Severn Road, Canton, Cardiff ... | Dec. 9, 1882 |
| 527 | Walker, W., Hawthorns, Saltburn-by-the-Sea ... ... ... | Mar. 5, 1870 |
| 528 | Walker, Wm., Jun., Assistant Inspector of Mines, Durham ... | Aug. 3, 1889 |
| 529 | Walker, William Edward, Lowther Street, Whitehaven ... | Nov. 19, 1881 |
| 530 | Wallace, Henry, Trench Hall, Gateshead ... ... ... | Nov. 2, 1872 |
| 531 | Wallau, Jacob, Messrs. Black, Hawthorn, and Co., Gateshead ... | Dec. 10, 1887 |
| 532 | Walters, Hargrave, Birley Collieries, near Sheffield ... ... | June 4, 1881 |
| 533 | Walton, J. Coulthard, Writhlington Coll., Radstock, *via* Bath | Nov. 7, 1874 |
| 534 | Ward, H., Rodbaston Hall, near Penkridge, Stafford ... ... | Mar. 6, 1862 |
| 535* | Ward, T. H., F.G.S., Assistant Manager, E.I.R. Collieries, Giridi, Bengal, India ... ... ... ... ... ... | Aug. 7, 1882 |
| 536 | Wardell, S. C., Doe Hill House, Alfreton... ... ... ... | April 1, 1865 |
| 537 | Watkyn-Thomas, W., M.E., Mineral Office, Cockermouth Castle | Feb. 10, 1883 |
| 538 | Wears, W. G., M.E. ... ... ... ... ... ... ... | June 9, 1888 |
| 539 | Webster, H. Ingham, Morton House, Fence Houses ... ... | April 14, 1883 |
| 540 | Weeks, J. G., Bedlington, R.S.O., Northumberland *(Member of Council)* ... ... ... ... ... ... ... ... | Feb. 4, 1865 |
| 541 | Weeks, R. L., Willington, Co. Durham *(Member of Council)* ... | June 10, 1882 |
| 542 | Westmacott, P. G. B., Elswick Iron Works, Newcastle... ... | June 2, 1866 |
| 543 | White, C. E., Hebburn Colliery, near Newcastle-on-Tyne ... | Nov. 4, 1876 |
| 544 | White, H., Walker Colliery, Newcastle-on-Tyne ... ... ... | 1866 |
| 545 | White, J. F., M.E., Wakefield ... ... ... ... ... | July 2, 1872 |
| 546 | White, J. W. H., Woodlesford, near Leeds ... ... ... | Sept. 2, 1876 |
| 547 | Whitehead, James, Brindle Lodge, near Preston, Lancashire ... | Dec. 4, 1875 |
| 548 | Whitelaw, John, 118, George Street, Edinburgh... ... ... | Feb. 5, 1870 |
| 549 | Whittem, Thos. S., Wyken Colliery, near Coventry ... ... | Dec. 5, 1874 |
| 550 | Widdas, C., North Bitchburn Colliery, Howden, Darlington ... | Dec. 5, 1868 |
| 551 | Wight, Edwd. S., Mount Perry, Queensland, Australia... ... | Dec. 12, 1885 |
| 552 | Wight, W. H., Cowpen Colliery, Blyth ... ... ... ... | Feb. 3, 1877 |
| 553 | Willis, J., 14, Portland Terrace, Newcastle (Retiring Vice-President, *Member of Council*) .. ... ... ... .. | Mar. 5, 1857 |
| 554 | Wilson, J. B., Wingfield Iron Works and Colliery, Alfreton ... | Nov. 5, 1852 |
| 555 | Wilson, J. D., Ouston House, Chester-le-Street ... ... .. | Sept. 11, 1873 |
| 556 | Wilson, John Robinson, c/o T. A. Walker, Esq., Contractor, Manchester Ship Canal, Manchester ... ... ... ... | June 9, 1883 |
| 557 | Wilson, Robert, Flimby Colliery, Maryport ... ... ... | Aug. 1, 1874 |
| 558 | Wilson, W. B., Thornley Coll., by Trimdon Grange, Co. Durham | Feb. 6, 1869 |
| 559 | Winstanley, Robt., M.E., 28, Deansgate, Manchester ... ... | Sept. 7, 1878 |
| 560 | Winter, T. B., Grey Street, Newcastle-on-Tyne ... ... ... | Oct. 7, 1871 |
| 561 | Wood, C. L., Freeland, Forgandenny, Perthshire .. ... ... | 1853 |
| 562 | Wood, Lindsay, The Hermitage, Chester-le-Street (Past-President, *Member of Council*) ... ... .. ... ... | Oct. 1, 1857 |
| 563 | Wood, Thomas, Rainton House, Fence Houses ... .. ... | Sept. 3, 1870 |
| 564 | Wood, W. H., Coxhoe Hall, Coxhoe, County Durham ... ... | 1856 |
| 565 | Wood, W. O., South Hetton, Sunderland *(Member of Council)* ... | Nov. 7, 1863 |
| 566 | Woolcock, Henry, St. Bees, Cumberland ... ... ... ... | Mar. 3, 1873 |
| 567 | Wormald, C. F., Mayfield Villa, Saltwell, Gateshead-on-Tyne ... | Dec. 8, 1885 |
| 568 | Wrightson, T., Stockton-on-Tees ... ... ... ... ... | Sept. 13, 1873 |
| 569 | Young, John A., 7, Tyne Vale Terrace, Gateshead ... ... | Dec. 10, 1887 |

## Associate Members.

| | | Elected. |
|---|---|---|
| 1 | Armstrong, J. H. St. Nicholas' Chambers, Newcastle-on-Tyne ... | Aug. 1, 1885 |
| 2 | Armstrong, T. J., Hawthorn Terrace, Newcastle-on-Tyne ... | Feb. 10, 1883 |
| 3 | Audus, T., Mineral Traffic Manager, North Eastern Railway, Newcastle-on-Tyne... ... ... ... ... ... ... | Aug. 7, 1880 |
| 4* | Bell, Thos. Hugh, Middlesbrough-on-Tees... ... ... ... | Dec. 11, 1882 |
| 5 | Burdon, A. E., Hartford House, Cramlington, Northumberland | Feb. 10, 1883 |
| 6 | Cochrane, Ralph D., Hetton Colliery Offices, Fence Houses ... | June 1, 1878 |
| 7 | Cooper, R. W., Solicitor, Newcastle-on-Tyne ... ... ... | Sept. 4, 1880 |
| 8 | Crawford, Wm., M.P., North Road, Durham ... ... ... | April 13, 1889 |
| 9 | Edwards, F. H., Forth House, Bewick Street, Newcastle-on-Tyne | June 11, 1887 |
| 10 | Fletcher, W., Brigham Hill, *via* Carlisle ... ... ... ... | Oct. 13, 1883 |
| 11 | Gosman, Fred., Mining Institute, Newcastle-on-Tyne (Cashier) | Oct. 12, 1889 |
| 12 | Guthrie, Reginald, Coal Trade Office, Newcastle-on-Tyne ... | Aug. 4, 1888 |
| 13 | Hedley, E., Rainham Lodge, The Avenue, Beckenham, Kent ... | Dec. 2, 1871 |
| 14 | Hedley, T. F., Jun., Valuer, Sunderland ... ... ... ... | April 24, 1887 |
| 15 | Henderson, C. W. C., The Riding, Hexham ... ... ... | Dec. 11, 1882 |
| 16 | Hooper, Edward, c/o J. H. Hooper, College Precincts, Worcester | June 4, 1881 |
| 17 | Hopper, J. I., Wire Rope Manufacturer, Tyne Dock, South Shields | Dec. 3, 1888 |
| 18 | Hutchinson, T. C., Hilda House, Middlesbrough ... ... ... | Aug. 3, 1889 |
| 19 | Johnson, F. D., Aykleyheads, Durham ... ... ... ... | Feb. 10, 1883 |
| 20* | Miller, N., 31, Hyde Lane, Hyde, near Manchester ... ... | Oct. 5, 1878 |
| 21* | Pease, Arthur, Darlington ... ... ... ... ... ... | Dec. 11, 1882 |
| 22 | Proctor, John H., Ironmonger, 29, Side, Newcastle-on-Tyne | June 8, 1889 |
| 23 | Redmayne, R. Norman, Chemical Manufacturer, &c., 26, Grey Street, Newcastle-on-Tyne ... ... ... ... ... | Oct. 12, 1889 |
| 24 | Ridley, Sir Matthew W., Bart., M.P., Blagdon, Northumberland | Feb. 10, 1883 |
| 25 | Scurfield, George J., Hurworth-upon-Tees, Darlington ... | Dec. 11, 1882 |
| 26 | Shaw, Saville, Durham College of Science, Newcastle-on-Tyne | April 13, 1889 |
| 27 | Snowball, Joseph, Seaton Burn House, Dudley, Northumberland | Feb. 10, 1883 |
| 28 | Wilson, Arthur P., 12, Barkston Mansions, South Kensington, London ... ... ... ... ... ... ... ... | Aug. 3, 1889 |

## Associates.

| | | |
|---|---|---|
| 1 | Chandley, Charles, Atherton Collieries, near Manchester ... | Nov. 6, 1880 |
| 2 | Guy, John George, M.E., Seaham Colliery, Sunderland... ... | Aug. 3, 1889 |
| 3 | Nicholson, J. H., North Seaton Coal Office, Newbiggen-by-the-Sea ... ... ... ... ... ... ... ... ... | Oct. 1, 1881 |

# Students.

| | | Elected. |
|---|---|---|
| 1 | Barrass, M., Tudhoe Colliery, Spennymoor ... ... ... | Dec. 10, 1883 |
| 2 | Bell, Walter, Nunnery Colliery Offices, Sheffield ... ... | Oct. 12, 1889 |
| 3 | Brown, Westgarth F., Alston House, Cardiff .. ... ... | Oct. 9, 1886 |
| 4 | Burn, Frank H., Harton Colliery, South Shields... ... ... | Feb. 9, 1889 |
| 5 | Carr, John Evelyn, Cowpen Colliery, Blyth, Northumberland .. | June 8, 1889 |
| 6 | Cochrane, Napier, Aldin Grange, Durham... ... ... ... | Dec. 8, 1888 |
| 7 | Cole, Colin, De Beers Mine, Kimberley, South Africa ... ... | Oct. 18, 1882 |
| 8 | Crawford, James Mill, Murton Colliery, near Sunderland ... | Dec. 11, 1882 |
| 9 | Forster, C. W., 6, Ellison Place, Newcastle-on-Tyne ... ... | June 10, 1882 |
| 10 | Forster, George W., Heworth Colliery, near Newcastle-on-Tyne | Oct. 8, 1887 |
| 11 | Gallwey, A. P., Ruby and Dunderburg Mining Company, Eureka, Nevada, U.S. ... ... ... ... ... ... | Oct. 2, 1880 |
| 12 | Haggie, Douglas, Thorncliffe Iron Works, Sheffield ... ... | April 14, 1883 |
| 13 | Hall, Fred. W., Ryhope Colliery, Sunderland ... ... .. | June 8, 1888 |
| 14 | Hare, Samuel, Brymbo Co., near Wrexham, North Wales ... | Aug. 2, 1879 |
| 15 | Harrison, R. W., Leicestershire Club, Leicester ... ... .. | Mar. 3, 1877 |
| 16 | Hay, W., Jun., Mapperley Coll. Co., Ltd., West Hallam, nr. Derby | Dec. 10, 1883 |
| 17 | Howard, Walter, c/o F. W. Schwager, Coronel, Chili ... ... | April 13, 1878 |
| 18 | Hurst, Geo., Seaton Delaval Colliery, Northumberland ... ... | April 14, 1883 |
| 19 | Hutt, E. H., Holdfast Main Reef Gold Mining Company, Limited, Boksburg, S. A. R. ... ... ... ... ... ... | Aug. 4, 1883 |
| 20 | Kirkhouse, E. G., 1, Edith Street, Consett, Co. Durham ... | Aug. 3, 1878 |
| 21 | Lishman, R. R., Celynen Colliery, Abercarne, *via* Newport, Mon. | June 9, 1883 |
| 22 | McMurtrie, G. E. J., Park Lane, Poynton, near Stockport ... | Aug. 2, 1884 |
| 23 | Nicholson, A. D., Eldon Colliery, Co. Durham ... ... ... | June 13, 1885 |
| 24 | Oates, Robert J. W., E.I.R. Collieries, Giridi, Bengal, India ... | Feb. 10, 1883 |
| 25 | Patterson, Thomas, Silksworth Colliery, Sunderland ... ... | April 13, 1889 |
| 26 | Peart, A. W., Bon-accord, Gelli, Ton-pentre, Pontypridd, Glam. | Nov. 4, 1876 |
| 27 | Pease, J. F., Pierremont, Darlington ... ... ... ... | June 9, 1883 |
| 28 | Potter, E. A., Cramlington, Northumberland ... ... ... | Feb. 6, 1875 |
| 29 | Pringle, Hy. Geo., Tanfield Lea Colliery, Lintz Green Station, Newcastle ... ... ... ... ... ... ... ... | Dec. 4, 1880 |
| 30 | Redmayne, R. A. S., Hetton Collieries, near Fence Houses ... | Dec. 13, 1884 |
| 31 | Richardson, Ralph, Eppleton Colliery, Fence Houses, Co. Durham ... ... ... .. ... ... ... ... | June 9, 1883 |
| 32 | Ridley, Wm., South Tanfield Colliery, Stanley, R.S.O., Newcastle-on-Tyne... ... ... ... ... ... ... | Dec. 11, 1882 |

| | | Elected. |
|---|---|---|
| 33 | Scott, Joseph S., East Hetton Colliery, Coxhoe, Co. Durham ... | Nov. 19, 1881 |
| 34 | Shute, Wm. Ashley, Westoe, South Shields ... ... ... | April 11, 1885 |
| 35 | Simpson, F. R., Cannock Chase Colliery, Walsall ... ... ... | Aug. 4, 1883 |
| 36 | Smith, Norman, The Bank, Haydon Bridge ... ... ... | June 8, 1888 |
| 37 | Stanton, Philip, Trimdon Grange, Co. Durham ... ... ... | Dec. 8, 1888 |
| 38 | Steavenson, C. H., Backworth Colliery, Newcastle-on-Tyne ... | April 14, 1883 |
| 39 | Sykes, Frank K., Springwell Villa, Bishop Auckland ... ... | Feb. 13, 1886 |
| 40 | Waugh, C. L., Ffalda Steam Coal Coll., Garw Valley, nr. Bridgend | Nov. 19, 1881 |
| 41 | Weightman, Percy O., Barrow Colliery, Barnsley ... .. | Oct. 12, 1889 |
| 42 | Wood, John, Coxhoe Hall, Coxhoe, R.S.O., Co. Durham ... | June 8, 1889 |
| 43 | Yeoman, Thomas, Willington Hall, Willington, Co. Durham ... | Feb. 14, 1885 |

## Subscribers under Bye-Law 9.

1 Ashington Colliery, Newcastle-on-Tyne.
2 Birtley Iron Company, Birtley.
3 Bridgewater Trustees.
4 Haswell Colliery, Sunderland.
5 Hetton Collieries, Fence Houses.
6 Hutton Henry Coal Company, Limited.
7 Lambton Collieries, Fence Houses.
8 Londonderry Collieries, Fence Houses.
9 Marquess of Bute.
10 North Brancepeth Coal Company, Limited.
11 North Hetton Colliery, Fence Houses.
12 Ryhope Colliery, near Sunderland.
13 Seghill Colliery, Northumberland.
14 South Hetton and Murton Collieries.
15 Stella Colliery, Hedgefield, Blaydon-on-Tyne.
16 Throckley Colliery, Newcastle-on-Tyne.
17 Victoria Garesfield Colliery, Lintz Green.
18 Wearmouth Colliery, Sunderland.

# CHARTER

OF

# THE NORTH OF ENGLAND

# Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING :

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased) ; THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased) ; Sir GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity ; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property ; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community ; that the Society has since its establishment diligently pursued its aforesaid

objects, and in so doing has made costly experiments and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. And whereas in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of Our Kingdom, We have been besought to grant to the said Lindsay Wood, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. Now know ye that We, being desirous of encouraging a design so laudable and salutary, of our especial grace, certain know-

ledge, and mere motion, have willed, granted, and declared, and do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of Us, Our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the Statutes of Mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectively at the rack rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial license and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments, not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. AND Our will and

pleasure is, and we further grant and declare that for the better rule and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. And we do hereby further will and declare that the said Lindsay Wood, shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectively shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. And we do hereby further will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. And we do further will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say : for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein ; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held,

and for convening the same and regulating the proceedings thereat, and for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. And we do further will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, Provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. In witness whereof we have caused these our Letters to be made Patent.

Witness Ourself at Our Palace, at Westminster, this 28th day of November, in the fortieth year of Our Reign.

By Her Majesty's Command,

CARDEW.

THE NORTH OF ENGLAND INSTITUTE

OF

# MINING AND MECHANICAL ENGINEERS.

## BYE-LAWS

PASSED AT A SPECIAL GENERAL MEETING HELD ON THE 8TH OF JUNE, 1889.

### I.—Constitution.

1.—The North of England Institute of Mining and Mechanical Engineers shall consist of Members, Associate Members, and Honorary Members. The Institute shall in addition comprise Associates and Students.

2.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Members and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council.

All Past-Presidents shall be *ex-officio* Members of the Council, so long as they continue Members or Associate Members of the Institute; and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

### II.—Qualifications of Members, Associate Members, Honorary Members, Associates, and Students.

3.—Members.—Every candidate for admission into the class of Members, or for transfer into that class, shall come within the following conditions :—He shall be more than twenty-three years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an Engineer for at least five years. This class shall also comprise every person who was an Ordinary Member, Life Member, or Student on the first of August, 1877.

4.—Associate Members shall be persons connected with or interested in Mining or Engineering, and not practising as Mining or Mechanical Engineers, or in some other branch of Engineering.

5.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines, or employed in analogous positions in other branches of Engineering.

7.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or other branch of Engineering, and such persons may continue Students until they attain the age of twenty-five years.

### III.—Election and Expulsion of Members.

8.—Any person desirous of becoming a Member, an Associate Member, an Associate, or a Student, shall be proposed according to the Forms A, B, C, or D respectively in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified The Form must be signed by the proposer and at least two other Member, or Associate Members, certifying a personal knowledge of the candidate.

Any person qualified to become an Honorary Member shall be proposed according to the Form E in the Appendix, in which Form the names usual residence, and qualifications of the candidate shall be distinctly stated. This Form must be signed by the proposer and at least five other Members or Associate Members, certifying a personal knowledge of the candidate, and the Council shall have the power of defining the time during which, and the circumstances under which the candidate shall be an Honorary Member.

Any Associate or Student desirous of becoming a Member, shall be proposed and recommended according to the Form F in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This Form must be signed by the proposer and at least two other Members, or Associate Members, certifying a personal knowledge of the candidate, and the proposal shall then be treated in the manner hereinafter described.

Every proposal shall be delivered to the Secretary, and by him submitted to the next meeting of the Council, who, on approving the qualifications, shall determine if the candidate is to be presented for ballot, and if it is so determined, the Chairman of the Council shall sign

such proposal. The same shall be read at the next Ordinary General Meeting, and afterwards be exhibited in the Institute's Hall until the following Ordinary General Meeting, when the candidate shall be balloted for.

A Student may become an Associate at any time after attaining the age of twenty-one years.

9.—The balloting shall be conducted in the following manner :—Each Member or Associate Member attending the meeting at which a ballot is to take place, shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form G in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members and Associate Members voting.

10.—Notice of election shall be sent to every person within one week after his election, according to the Form H in the Appendix, enclosing at the same time a copy of Form I, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise shall become void.

11.—Every Member having signed a declaration in the Form I, and having likewise made the proper payment, shall receive a certificate of his election, according to the Form J.

12.—Any Member, Associate Member, Associate, or Student elected at any meeting between the Annual Meetings shall be entitled to all Transactions issued in the Institute's year, so soon as he has signed and returned Form I, and paid his subscription.

13.—The Transactions of the Institute shall not be forwarded to those whose subscriptions are in arrear on the 1st of May in each year.

14.—Any person whose subscription is more than one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form K in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter to his last recorded address in the books of the Society, according to the Form L in the Appendix, of declaring that the defaulter has ceased to be a Member.

15.—In case the expulsion of any person shall be judged expedient by ten or more Members, or Associate Members, and they think fit to

draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the next meeting of the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half of the Members or Associate Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form M in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the Members and Associate Members present at such meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form N in the Appendix.

## IV.—Subscriptions.

16.—The annual subscription of each Member and Associate Member shall be £2 2s., of each Associate and Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

17.—Any Member or Associate Member may, at any time, compound for all future subscriptions by a payment of £25, or on such other conditions as the Council may, in writing, accept. Every person so compounding shall be a Member or an Associate Member for life, as the case may be. Any Associate Member so compounding who may afterwards be qualified to become a Member, may do so, by election, in the manner described in Bye-law 8.

18.—In case any Member, Associate Member, or Associate who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed by them for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a Member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the

composition mentioned in Bye-law 17, and may thereupon release him from any or all future subscriptions, and permit him to resume his former rank in the Institute.

19.—Owners of Collieries, Engineers, Manufacturers, Railway Companies, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to tickets to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society ; and for every additional £2 2s., subscribed annually, two other persons shall be admissible ; and each such subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Transactions of the Institute sent to him.

## V.—Election of Officers.

20.—The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election to any office, with the exception of any President who may have held office for the two immediately preceding years, or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past year, and when any such attendances are equal, the Council shall decide between them ; but any such Member or Associate Member shall be eligible for re-election after being one year out of office.

Any Retiring Vice-President or Councillor who may be ineligible for re-election shall nevertheless be eligible to any other office.

21.—Each Member, and Associate Member, shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form O in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other

Member or Associate Member eligible for each respective office ; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease, expulsion, or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant office or offices, and a new Officer or Officers shall be elected at the first succeeding Ordinary General Meeting.

23.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

## VI.—Duties of the Officers and Council.

24.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

25.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member or Associate Member present, to take the chair at the meeting.

26.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members and Associate Members.

27.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

28.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institute. Such Committees shall make a report to the Council, who shall act thereon, and make use thereof as they see occasion.

## VII.—Communications and Memoirs.

29.—All papers shall be sent for the approval of the Council at least twenty-one days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and immediate notice shall be given to the writer whether it is to be printed or not.

30.—The copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

31.—Twenty copies of each paper printed by the Institute shall be presented to the author for private use.

32.—All proofs of reports of discussions, forwarded to any person for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

33.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

## VIII.—Meetings of the Institute.

34.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council ; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council.

35.—All donations to the Institute shall be acknowledged in the Annual Report of the Council.

36.—A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members or Associate Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

37.—The Members, Associate Members, Honorary Members, Associates and Students, shall have notice of, and the privilege to attend, all Ordinary General Meetings and Special Meetings.

38.—Every question, not otherwise provided for, which shall come before any meeting, shall be decided by the votes of the majority of the Members and Associate Members then present.

39.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote.

Any Member or Associate Member shall have power to introduce two strangers (see Form P) to any General Meeting, but they shall not take part in the proceedings except by permission of the meeting.

## IX.—Property of the Institute.

40.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

41.—The Institute Hall and Reading Room shall be open to the Members, Associate Members, Honorary Members, Associates and Students on every week day, from 10 a.m. to 5 p.m., except on such special day or days when the Council shall think it expedient to close the rooms and suspend the circulation of Books. Books shall be issued according to regulations from time to time approved by the Council.

42.—No duplicate copies of any portion of the Transactions shall be issued to any Member, Associate Member, Associate or Student, unless by order from the Council.

## X.—Alteration of Bye-laws.

43.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

I hereby approve the foregoing Bye-laws,

HENRY MATTHEWS,

One of Her Majesty's Principal Secretaries of State.

*Whitehall,*
*29th June, 1891.*

# APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-three years of age, and desirous of becoming a Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I propose him to the Council as a proper person to be admitted a Member.

Signed.....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted a Member.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18 .

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of becoming an Associate Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to be admitted an Associate Member.

Signed.....Member or Associate Member.

Dated this..... day of.. .....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an Associate Member.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Associate Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18 .

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[FORM C.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of becoming an Associate of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to be admitted as an Associate.

Signed .....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted as an Associate.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

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[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Associate of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18 .

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[FORM D.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being under twenty-five years of age and desirous of becoming a Student of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to be admitted as a Student.

Signed..... .....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted a Student.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Student of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18 .

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[FORM E.]

I recommend A. B. [Christian Name, Surname, Occupation, and Address in full], from *personal knowledge*, as a person in every respect qualified to become an Honorary Member of the North of England Institute of Mining and Mechanical Engineers, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 5.*]

On the above grounds, I propose him to the Council as a proper person to be admitted an Honorary Member.

Signed.....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an Honorary Member.

FROM PERSONAL KNOWLEDGE.

.....
.....
.....
.....
.....

} Five Members or Associate Members.

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[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18 .

[FORM F.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a.....of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-three years of age, and being desirous of becoming a Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I propose him to the Council as a proper person to be admitted a Member.

Signed.....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted a Member.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

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[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this..... .....day of.....18 .

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[FORM G.]

List of the names of persons to be balloted for at the General Meeting on....., the.....day of.....18 .

MEMBERS :—

.....

.....

ASSOCIATE MEMBERS :—

.....

.....

HONORARY MEMBERS :—

.....

.....

ASSOCIATES :—

.....

.....

STUDENTS :—

.....

.....

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

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[FORM H.]

SIR,—I beg leave to inform you that on the.....day of..... you were elected a... .....of the North of England Institute of Mining and Mechanical Engineers. In conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me with your signature, and until your first annual subscription be paid, the amount of which is £..... ..., or, at your option, the life-composition of £25.

If the subscription is not received within two months from the present date, the election will become void under Bye-law 10.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

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[FORM I.]

I, the undersigned, being elected a..... ..... . ...of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being ; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can ; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this.....day of.....18 .

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[FORM J.]

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

*Founded 1852. Incorporated by Royal Charter, A.D., 1876.*

These are to certify that A. B. [Christian Name, Surname, Occupation, and Address in full] was elected a Member of the North of England Institute of Mining and Mechanical Engineers, at a General Meeting held on the. ... .....day of .. .....18 .

Witness our hands and Seal this .....day of.....18 .

.....President.

SEAL.

.....Secretary.

[FORM K.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 14, and to remind you that the sum of £.....of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

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[FORM L.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 14, the Council have determined that unless payment of the amount £.....is made previous to the.....day of .....next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, sir, yours faithfully,

.....Secretary.

Dated..... .....18 .

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[FORM M.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 15.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

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[FORM N.]

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the..... .....day of.....18 ....., according to the provisions of Bye-law 15, you have ceased to be a.....of the Institute.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

[FORM O.]

BALLOTING LIST,.....

Ballot to take place at the Annual Meeting on.....18.....at Two o'clock, p.m.

The names of persons for whom the voter does *not* vote must be erased, and the names of other persons eligible for re-election may be inserted in their place, provided the number remaining on the list does not exceed the number of persons to be elected.

PRESIDENT—Not more than ONE NAME to be returned, or the vote will be lost.

——— President for the current year eligible for re-election.*

———
——— } New Nominations.*

VICE-PRESIDENTS—Not more than SIX NAMES to be returned, or the vote will be lost.

The Votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter.

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———
——— } Vice-Presidents for the current year eligible for re-election.

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———
——— } New Nominations.

COUNCIL—Not more than EIGHTEEN NAMES to be returned, or the vote will be lost.

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——— } Members of the Council for the current year eligible for re-election.

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———
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———
———
——— } New Nominations.

Any list returned with a greater number of Names than
ONE PRESIDENT,
SIX VICE-PRESIDENTS, or
EIGHTEEN COUNCILLORS,
Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

* To be inserted when necessary.

Ex-Officio Members of the Council for the ensuing year :—

——— } Past-Presidents.

——— } Retiring Vice-Presidents.

Extract from Bye-law 21.

Each Member, and Associate Member, shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. [See Form O in the Appendix.] A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 20 :—

As President.....

As Vice-President.....

As Councillors.....

[FORM P.]

Admit.....

of.....

to the General Meeting on Saturday, the.....

(Signature of Member, Associate Member, Associate, or Student).....

The Chair to be taken at Two o'Clock p.m.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor).....

Not transferable.

1282

# NORTH OF ENGLAND INSTITUTE

OF

# MINING & MECHANICAL ENGINEERS

GENERAL MEETING, SATURDAY, OCTOBER 13TH, 1888.

Mr. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting.

The following gentlemen were elected :—

ASSOCIATE MEMBERS—

Mr. A. C. CHAPMAN, Newcastle-on-Tyne.
Mr. T. L. ELWEN, Littleburn Colliery.
Mr. T. W. VASEY, Littleburn Colliery.
Mr. H. L. STANSFELD, Littleburn Colliery.

Mr. JOHN MORISON read the following paper on "The Danger attending the Use of Light Mineral Oils for Lubricating Air-Compressing Machinery" :—

# THE DANGER ATTENDING THE USE OF LIGHT MINERAL OILS FOR LUBRICATING AIR COMPRESSING MACHINERY.

By JOHN MORISON.

Upon the 1st March, 1883, an explosion of an air receiver occurred at Ryhope Colliery, Sunderland, the particulars of which are briefly as follows:—

The air compressor supplying the receiver in question was working at a pressure of 57 lbs. per square inch, and the receiver consisted of a cylindrical shell with hemispherical ends, the shell being 29 feet long and 6 feet in diameter. The receiver was close to the air compressor. On the night of the accident the attendant had oiled the air cylinders shortly before the explosion occurred. The explosion was accompanied by a loud report, and a large volume of flame was observed to shoot upwards, and shortly subside, but left some oily matter inside the receiver burning. The receiver was torn asunder, and a considerable amount of damage was done to pipes in the shaft and bratticing in their neighbourhood, details of which will be found in the Report by the Committee appointed by this Institution to report upon the matter, and in a report by Mr. T. J. Richards, Engineer, Surveyor to the Board of Trade.

The reports in question both point to the explosion having occurred through the use of a mineral oil; but in neither report is the flash point of the oil used given, nor is it recorded what the actual temperature of the compressed air as it left the compressing cylinder was.

The Committee thus summarise the result of their investigation:—"The bursting of the No. 1 air receiver must, therefore, have been produced by the explosion of some substance inside. The temperature in the No. 1 air receiver must have been somewhat high, and must have heated the plates to a high temperature before

the explosion, otherwise they could not have been raised to a white heat in the short time that the fire was allowed to burn after the explosion. The bursting of the air pipes in the shaft, and the damage done in the shaft itself appears to have resulted from the momentum given to the air in the pipes by the explosion, which (it is supposed) took place in the No. 1 air receiver. . . . . It is possible that the flashing point of the mineral oil forming part of the lubricant used in the air compressing cylinder was less than the temperature of the compressed air. . . . . ."

Reference is also made by the Committee to the presence of coal-dust, and experiments by Professor Bedson, of the Durham College of Science, Newcastle-upon-Tyne, will be found recorded in an appendix to the report; but although dust is mentioned, and the experiments of Professor Bedson go to suggest a danger in its presence, the Committee do not appear to have attributed much share in the result to the presence of dust.

If the observations which I have recorded, and which are the subject of this paper, are of any value, their value is due to the experience given by the Ryhope explosion, and to the careful reports which I have referred to, and I am also indebted to Mr. Hall, of Ryhope, for a perusal of his notes upon the subject. Without this experience and information, it would have been impossible for me to take advantage of the opportunity which was afforded to me of throwing some light, as I hope, upon the incident at Ryhope by the observation of the incident which I now record.

Upon the 13th February, this year, my attention was called to the condition of the discharge pipes leading from an air compressor, working at Newbattle Colliery, Dalkeith, to the receiver. The pipes are 6 inches inside diameter, of cast iron, and with flanged joints, the joint being made with india-rubber insertion screwed up between the flanges. The receiver is 50 feet from the air cylinder, and air is compressed up to 50 lbs. per square inch, the compressing cylinder being 24 inches in diameter by 4 feet stroke. The receiver is blown off daily. The cylinder has no means for cooling the air during compression, except a tank in which the cylinder is fixed in the usual way, which causes the cylinder to be surrounded by water. The temperature of the air leaving the compressor has been frequently and regularly taken, and when compressing up to 50 lbs. per square inch it varies from 320 degs. to 370 degs. Fah., and I may state, from frequent observations of this compressor and others, that this is a common and usual

temperature in the discharge pipe behind the valves, where no means of cooling, except the water jacket described, is used.

I found upon enquiry that the attendant had observed for a short time previous to the incident which more particularly bears upon my subject, that the pipes leading to the receiver appeared to be unusually hot, but he did not consider it of sufficient importance to stop his engine. Shortly after this two of the pipe joints between the cylinder and the receiver began to blow, and upon going to see what was the cause of this, he found sparks blowing with the air out of the joints, and the pipe nearly red hot. When the joints were taken out they were found to be charred and burnt through, and afterwards, upon disconnecting the pipes for the purpose of examination, their interior was found to be coated with a charred deposit, the residue of the combustion of lubricating oil which had been used in the cylinder and gradually deposited in the pipes. This had evidently been incandescent.

Attention was next naturally given to the oil used, and as the oil which the attendant had instructions to use was lard oil, and beyond suspicion, having been used for years, and was selected for the purpose under the knowledge of what had occurred at Ryhope, I was convinced, upon finding that another oil had been used by the attendant for a short time previously, owing to the temporary want of lard oil, that the oil used was the cause of the damage.

The oil which had been substituted was a mixture of a heavy mineral oil and an oil bought as "colza," and upon examination of samples of these, the heavy oil proved to be a natural oil with a high flash point (above 480 degs. Fah.), and there was nothing in it, so far as could be judged, to bring about the result described. The "colza" oil had a specific gravity of ·910 and a strong mineral bloom, much intensified on heating, and above all flashing at 295 degs. Fah., and it was evident from this that the "colza" was chiefly in the name, the balance being made up probably of a mixture of thickened cotton seed oil (lardine) and intermediate mineral about ·870 gravity.

There are some few differences between the occurrences described and the one at Ryhope, but upon the whole the cases are parallel, and while the similarities throw great light I think upon the Ryhope explosion, the differences in the circumstances also may act as a guide to a true theory upon the cause of both occurrences. If I recapitulate the similarities and dissimilarities which I think

bear upon or accentuate the cause of both occurrences, I may be more easily followed.

1st.—*Similarities.*—Both were using light mineral oil.

A high temperature was attained by some means in both.

2nd.—*Dissimilarities.*—An explosion at Ryhope, none at Newbattle.

The receiver was further off the compressor at Newbattle.

The receiver was blown off regularly at Newbattle (this is not recorded at Ryhope).

The insertion joints gave an indication of fire at Newbattle; it is not recorded that there happened to be such a means of indicating fire at Ryhope.

There was no coal-dust at Newbattle.

It can hardly be denied that the cause in both cases was the oil and this point, I think, hardly requires discussion; and the more serious result in the one case than in the other is probably accounted for more or less by all the dissimilarities which I have pointed out, but chiefly, I think, in the probability that in the receiver at Ryhope there was an accumulation of oil, while at Newbattle there could not be such an accumulation owing to the fact that the receiver was blown off. The other two points which come next in order of importance are that the receiver was further off the compressor at Newbattle, and that the burning out of the joints indicated combustion before heat of any importance reached the receiver. The absence or presence of coal-dust has, I think, little to do with the result. It is suggested in the report by the Committee that flame might be communicated to the explosive gas generated by the vaporisation of the oil by the spontaneous combustion of a piece of waste, or of the collection of oil, etc., in the receiver; but it appears unnecessary to seek for such a cause, for it seems evident that if the temperature of the compressor at any point, say beyond the discharge valves, is 360 degs., which is possible and common in any compressor working without special means of cooling beyond the water-jacketed cylinder, the temperature at some point in the interior of the cylinder at the moment of maximum compression—and, therefore, when the discharge valves are open—must far exceed this, and would be sufficiently high to vaporise oil such as was used in both cases and by flashing to ignite the vapour.

The proportion of air present might be too high to permit of an explosion, but the ignition of the vapour would cause combustion, from the effect of which the temperature would rise gradually and extend along the pipes, being fed and intensified by the distillation of any oily matter lying in the pipes; and if this action were allowed to proceed until a reservoir of oil such as the receiver were reached, the oil found there would be vaporised until the proportion of oil gas in the air reached a point at which the mixture was explosive.

I think that what little doubt existed as to the cause of the Ryhope explosion is dispelled by the fact of a similar oil producing results which have been visible, and which are sufficient to account for the explosion, and the necessity is apparent of testing the flash point of all oil used in air compressing machinery, or of obtaining a guarantee from the maker as to the flash point.

I have thought it well to bring these facts and conclusions before the Institute, as there is a great and imminent danger which cannot be too prominently brought under the notice of members who use air compressing machinery.

The SECRETARY: Professor Bedson had an opportunity of reading a proof of Mr. Morison's paper, and was anxious to be at this meeting, but has had to go to Middlesbrough. He has written the following in the form of a letter:—

October 12th, 1888.

MY DEAR LEBOUR,

I very much regret that it is impossible for me to attend the meeting of the Mining Institute to-morrow, and be present at the reading of Mr. Morison's paper on "The Danger Attending the Use of Light Mineral Oils for Lubricating Air Compressing Machinery." As this is a subject in which I take a great interest, and as Mr. Morison in his paper remarks on the explosion of the Ryhope receiver, and on the Report of the Committee appointed to investigate this matter, I should be obliged if you will kindly read the following at the meeting.

In the first place Mr. Morison's summary of the result of the committee's investigations and conclusions is not complete, the passages quoted show that Mr. Morison cannot have seen the final Report presented by the Committee to the members of the Institute. Not only is this evidenced by the incompleteness of the quotations, but also by the statement that no mention is made of the "flashing point" of the oil used at Ryhope, which it will be found in the Report is given as 365 degs. F. I might quote other passages which point to the same conclusion, but as probably there will be other members of the Committee present no doubt these discrepancies will be duly noted.

The occurrence described by Mr. Morison is of great interest, as it supplies much valuable information considered in connection with the Ryhope explosion. First, the temperature of the air leaving the compressor is definitely stated to have varied from 320 degs. to 370 degs. F., such information was wanting in the evidence obtained in connection with the Ryhope explosion. Secondly, the heating of the pipes between the compressor and the receiver at Newbattle, the

charring of the joints and the deposit in the pipes themselves, afford most valuable evidence of a very high temperature having been reached. It would be interesting to examine this deposit. I should like also to know what is the composition of the material drawn off from the receiver when it is blown off. Does this consist merely of oil, or is it a mixture of lubricant and some matter, such as that found lining the Ryhope air receiver?

In seeking for an explanation of the Ryhope air receiver, I have stated that two matters must be borne in mind. (1) The production of a temperature sufficiently high to ignite an explosive mixture of air and a combustible gas. (2) The production of an explosive mixture.

As will be seen from the Appendix to the Report of the Ryhope Committee I concluded that in the case under consideration, the chief heat producer was to be found in the carbonaceous deposit found lining the pipes and receiver, the production of heat being effected by the oxidation of this material by air passing over it and having its temperature raised by compression.

To simplify the matter I experimented with certain of the components of this mixture and first studied the effect of heating coal-dust alone in a current of air, with the result that it was found possible to ignite the coal-dust by heating it to a temperature varying from 291-320 degs. Fah. Further, when coal-dust is mixed with 30 per cent. of its weight of the oil used at Ryhope as a lubricant, the ignition of the dust takes place at a slightly higher temperature and the inflammation takes place more slowly, in fact the coal-dust, etc., do not ignite until the greater proportion of the oil has been vaporised.

The occurrence at Newbattle differs from that at Ryhope, as Mr. Morison points out, in the absence of an explosion, consequently we have only to consider in what way has the heat been produced which would raise the pipes near the compressor to the temperature spoken of in the paper. The conclusion that the "oil" has been the cause in both cases cannot be summarily dismissed. What do we know of the oil used at Newbattle? Simply that it is a mineral oil—or in part a mineral oil, and has a flashing point of 295 degs. Fah., *i.e.*, 70 degs. Fah. below the flashing point of the oil used at Ryhope. In other words that this oil consists chiefly of hydrocarbons of the paraffin series, and that it gives off vapours when heated to 295 degs. Fah. which would ignite—provided a light were applied to them.

The question now arises how can these vapours be ignited, granting that the temperature of the air, produced by compression, suffices to vaporise the lubricant, or send a fine spray into the pipes and receiver. There is no difficulty in imagining this to take place, but the "flashing" of the vapour is another question. And here is the whole difficulty of the case. Where is the heat to come from which will raise the vapour or a portion of the oil to its ignition point. The "flashing point" must not be confused with the "ignition point," the former simply being the temperature at which an imflammable liquid gives off vapours in sufficient quantity to be ignited by a light, the latter being the temperature to which the vapours must be raised in order that they may burn. Whilst the oil used at Newbattle is known to have a flashing point of 295 degs. F., there is nothing stated with regard to its "ignition point," or the temperature of ignition of its vapour. I am not aware that any direct experiments have been made to determine the temperature of ignition of the vapours given off from such oils, but I should imagine a temperature at least of dull redness would be required to start ignition. How then is such a temperature to be reached? My experiments suggest that such temperatures can be obtained when working air compressing machinery, such as that used at Ryhope or Newbattle, by the accumulation of the heat produced by the slow oxidation of the lubricant or oxidisable materials forced into the

receiver and pipes. Consequently, if the oil is to be considered the sole cause of the phenomena it must be demonstrated not only that it is in part volatilised at the temperatures of working, but that it undergoes oxidation under these same conditions, and that the heat produced would suffice to ignite the vapour of the oil, and produce the charred deposit, such as Mr. Morison describes as existing in the pipes between the compressor and the receiver. If this be demonstrated, and I do not see that it is impossible, then greater weight must be given to the part played by the "oil" than perhaps I have done in the appendix to the Report already referred to. But if it is a question between coal-dust and a mineral oil as heat producers when undergoing slow oxidation, I should imagine that the preference must be given to the more easily oxidisable coal, rather than to the stable hydro-carbons constituting the oils used.

Yours faithfully,

P. Phillips Bedson.

The President: We shall be very glad to hear any remarks upon these two papers.

Mr. Steavenson said the paper enabled them to draw a moral in regard to the use of oil for lubricating purposes, and that was always to test its flashing point. Another moral was that they should not use mineral oils at all for such purposes. For many years he had had an air compressor with water, and the temperature was about 90. He believed he was correct in saying that the air expanded 1·450 of its volume for each degree of heat, and consequently they would not be very far off double the volume of air when the heat got to 370 degs. The entire air passed the cylinders, and, when it became cold, passed back into half the volume. By the use of water the air was kept cool, there was an economy in power, and the risk of explosions was avoided.

Mr. Walton Brown said he had intended to make some remarks upon Mr. Morison's paper, but Professor Bedson had put his views so clearly, that there remained nothing more to say. The main difference between the two cases, was that at Ryhope there was a pure explosion, but at Newbattle there was no explosion. Mr. Morison did not state the ignition point.

The Secretary said he ought to explain that Mr. Morison's paper having been written before the publication of the final Report of the Committee on the Ryhope explosion, it had been written by Mr. Morison under a decided disadvantage. The Ryhope Committee's report was on the point of publication, and no doubt anything which now appeared to be a discrepancy, would cease to be so when Mr. Morison had the opportunity of seeing what really were the final results of the Committee's investigations. He thought Mr. Morison must have seen some early proof of the Committee's Report, which was liable to considerable alterations and additions.

Under these circumstances, it would be, perhaps, scarcely fair to discuss Mr. Morison's paper fully to-day.

Mr. STRATTON thought Mr. Morison had said he found a complete absence of coal-dust at Newbattle; but he did not really show there was no coal-dust. The explosion being at a colliery, there might be the same chance of their being coal-dust the same as at Ryhope.

Mr. W. N. ATKINSON said it appeared to him that Mr. Morison's account of what occurred at Newbattle gave a key to what caused the explosion at Ryhope. Mr. Morison stated that sparks were thrown out at the joints of the pipes, showing there was something in a state of great heat inside. Then Professor Bedson stated that it was necessary not only to account for the mineral oil being raised to its flashing point, but to some higher temperature, in order to account for its ignition. If what Mr. Morison related as seen at Newbattle also took place at Ryhope, then there was the means of ignition—a higher temperature than the flashing point of oil.

Mr. WALTON BROWN: Professor Bedson shows plainly that coal-dust, with and without oil, gradually inflamed, and got into a state of glowing ignition, and in that way into a state to ignite gas. Mr. Morison has not done this.

Mr. W. N. ATKINSON: In the case of Newbattle, there must have been some solid substance inside the pipes to account for the blowing off of sparks, either carbonised oil or coal-dust.

Mr. G. B. FORSTER: Perhaps the weeze was burning.

Mr. MORISON: The sparks would be caused by the deposit of the charred oil found in the pipes afterwards, and which had evidently been forming for some time.

Mr. STEAVENSON said that when he first spoke it was speaking from memory, and he now found that in Ure's Dictionary of the Arts it was stated that "supposing the side of the regenerator nearest the working cylinder is heated to a high temperature, the air, in passing through it, takes up about 450 degs. of the 480 degs. of heat required to double the volume of the air." So, if the air passed out at 370 degs., it was something near three-fourths larger in volume than if properly cooled down. Therefore, the power used in compressing it was wasted when the air got outside and cooled.

Mr. W. N. ATKINSON said the explosion at Ryhope was not the only one recorded. On the 16th August, 1885, a receiver, used as a reservoir for compressed air, at Carn Bora Mine, Cornwall, exploded.

The receiver was originally a steam boiler, 30 feet long and 6 feet 6 inches diameter, with $\frac{5}{16}$th plates. The explosion was of a violent character; and it was attributed to the ignition of the vapour from cheap mineral oil used for lubricating the air compressor cylinders.

Mr. MORISON said he was placed at rather a disadvantage in replying to the discussion, especially with respect to Professor Bedson's remarks, by not having seen the final report of the Ryhope Explosion Committee. He had seen a manuscript report, which was given to him by the late Secretary of the Institute, and when he received it he understood it was the final report. Of course, in the paper, he took out some points to which Professor Bedson referred, which he (Mr. Morison) considered incomplete in the report, but which he now found were rightly recorded by Professor Bedson. It would be desirable that he should defer any detailed reply to Professor Bedson's remarks until he had had an opportunity of studying his statements. He might state generally that the composition found upon blowing off the receiver at Newbattle appeared to be a mixture of oil and water; the water, he supposed, being admitted by the moisture of the air, and condensed in the receiver when it arrived at that point. There was a considerable deposit in the pipes of carbonised oily deposits, to which Professor Bedson referred. While using the compressor they had to take off the valve covers, and there were in the receiver very extensive deposits of matter resembling hard vulcanite, which was deposited upon the valves. Throughout the whole length of the pipes to the air receiver this matter was found when the pipes were taken out after the occurrence took place. It seemed to him to be easy to imagine that when matter of this description was heated to a temperature such as was found there of 365 degs., and oxydation taking place, it would be very simple for that temperature to increase along the pipes, and gradually accumulate until it came to the dull-red heat Professor Bedson referred to, as necessary to fire the gas from the oil-fed vapour. He would rather that some scientific man would take up this matter, and speak upon it at the adjourned discussion. As to the coal-dust, mentioned by Mr. Stratton, there was not found coal-dust at Newbattle, because the receiver was situated some distance from the pit, and besides the coal there did not make much dust, as it was hard and cannel coal, and not coal like that found in Northumberland and Durham. The compressor at Newbattle was 300 yards from the screens, and there was practically no dust present. As to the residue found in the pipes, it was evidently the

residue of oil. Mr. Stephenson's remarks as to the use of oil were probably very correct as to the power which was lost, but the point which he (Mr. Morison) wanted to bring out in the paper was—knowing that a great many people used oil, and preferred oil—that there was danger in connection with it. The use of water no doubt would reduce the temperature, and altogether obviate the danger which he pointed out; but it had disadvantages, such as interfering with the condition of the cylinders, which might be objected to. As a matter of fact, in the bulk of cases in air compression, oil was used in the cylinders, and hence the necessity he saw of drawing attention to the danger existing. He hoped to reply more fully to the discussion when he had had the opportunity of studying the remarks more fully.

Mr. T. E. FORSTER asked Mr. Morison how the oil was injected into the air cylinders; was it done by means of an ordinary oil cup, or how was it done? With an automatic self-feeding oil cup there was no doubt the quantity of oil used for lubricating purposes would be minimised very much, as compared with an old-fashioned oil cup.

Mr. MORISON replied that the oil was introduced into the air cylinders simply by snifting it in at the valve at intervals. A sight feed would be inapplicable, seeing the drops were regulated by the condensed steam. This could not be applied with air. He saw some difficulty in getting a lubricator such as Mr. Forster suggested—to feed air cylinders regularly; but there was no doubt such a thing would minimise the oil required; but still it would not obviate the danger which arose when oil was used, because it would only be a matter of time before the surplus oil would accumulate in the receiver and pipes, and form the gas.

Mr. WALTON BROWN: Will Mr. Morison forward to Professor Bedson some of the deposit found in the pipes at Newbattle?

Mr. MORISON: I will do so if I can.

The PRESIDENT said the members were very much obliged to Mr. Morison for the paper which he had read. The importance of making known the result of the Ryhope explosion enquiry was shown in the bringing forth of observations upon similar subjects. He moved a vote of thanks to Mr. Morison.

Mr. STEAVENSON seconded the vote of thanks, which was agreed to.

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A paper by Mr. James Hunter on "Charles Pit and Flaggy Creek Pit Heading, Waratah Colliery: Description of a Survey," was next read as follows:—

# CHARLES PIT—FLAGGY CREEK PIT HEADING: DESCRIPTION OF THE SURVEY.

By JAS. HUNTER, M.E.

It is not the intention of the writer to attempt a lengthy paper on mining surveying in general, but simply to tender a short description of the method followed in conducting the survey of the heading, or connection, now existing between the Waratah Coal Company's Charles Pit and Flaggy Creek shaft, in the district of Newcastle, New South Wales. As is shown in the accompanying diagram (Plate I.), the shafts are situated ninety-six chains, twenty-eight links apart, the country being remarkable for its rugged nature, as a glance at the section will show. Perhaps mention should be made of the fact that these shafts were not otherwise connected by underground workings, for had they been the work of finding and applying a bearing of a direct course would have been simple. The first work done in connection with the survey, was the running of a traverse along the clearest route between the two shafts, and from this datum a direct bearing and distance were computed, and as the theodolite was a very primitive one, having been in use in this colony for upwards of twenty-five years, the surveyor (Mr. H. O. Prytherch), deemed it advisable to test the bearing and distance thus calculated by running the same on the surface, and was not the least surprised to find an error of one chain, five links. At this stage of the proceedings, a halt in the survey was made, pending the purchase of a new five inch transit theodolite, by Messrs. Troughton and Simms, of London. With this instrument and a steel band (100 links), the traverse was repeated, and a new bearing and distance calculated and run successfully. The work being satisfactory, it was resolved to adopt this line for the heading. At this time (June 1st, 1886) the Flaggy Creek shaft having bottomed the coal, the circumferentor was resorted to, to start the heading away from the pit bottom, as no

permanent place existed at which to use the theodolite. As the heading proceeded about one hundred yards, a more reliable means was applied, namely, the lowering of the surface line with fine copper wires. Two wires were procured and rolled on small drums, four inches in diameter, and nine inches long, and suspended into the shaft three feet apart, and then adjusted to their exact position, with the theodolite fixed on the surface line at such a distance from the shaft as enabled the observer to see the wires distinctly. This having been accomplished, the "rapps" were given to the overman and his assistants below to range out the longest line possible. This line was subsequently carried into, and fixed permanently in the roof at the face, in the usual manner. Four months later (October 12th, 1886), the Charles Pit having bottomed the lower seam, the same operation was gone through here. The line thus fixed at each end was shifted into the face by the overman at intervals of fifty or sixty yards, by the naked eye, and checked by the surveyor with the theodolite, at intervals of four hundred yards. In June, 1887, however, a general check on the whole of the work was entered into, namely, the surface line run and lowered into the shafts as before, and a line ranged below at each end. With these lines a traverse was made from each shaft bottom to their respective "face." Hence a complete traverse was obtained between the then existing faces and the bearing and distance between these points computed, and when applied to the heading it was found to be coincident with the former. The traverses were considered preferable in the general check owing to the "lines" being carried within eighteen inches of the "rib." From this stage the lines were carried into the face by the overman at intervals, as before stated, up to the time of "holing." The junction was effected as indicated on the plan. In conclusion, the following remarks may be made with safety:—The most important points observed in the work were that the five adjustments of the transit were perfect, that the chain was used with an equal tension, and, in addition, accuracy in computations, and care in operating. All the calculations were made by logarithmic sines and cosines, and checked by naturals. The work having been completed in the presence of the company's directors on September 2nd, 1887, and, having given entire satisfaction, they deemed it worthy of a celebration, which they did in a manner worthy of themselves, by tendering a liberal banquet to all connected with the colliery.

## VENTILATION OF HEADING.

The Flaggy Creek shaft is nine feet in diameter, and two feet of this was divided by an inch Oregon pine brattice, and along the heading by sailcloth six feet wide, specially tarred with a mixture of Stockholm tar and linseed oil, which withstood the moisture and kept the air splendidly. A fan made at the colliery shops wholly of iron, four-and-a-half feet in diameter, and driven by a belt from a pair of six inch vertical engines geared 5 to 1, and averaging 60 to 70 strokes of the latter, compressed the air down the small division of shaft and into the face, where a good current was always felt so that a mile or more could equally as well have been driven with the same appliances. The main Charles Pit is fifteen feet in diameter, and the heading was similarly bratticed (leaving five feet for tramway), as above the return air ascending the adjoining upcast shaft. The seam generates fire-damp, but the ventilation being so good rendered safety-lamps unnecessary. Ninety to one hundred yards per fortnight was the average progress of the heading driven night and day from both ends. The levels of the heading from both sides were posted up and placed on the section fortnightly, and on communicating were found to be correct. The point of communication in the heading was so exact that it could not be detected without a mark being made specially in the side of same.

## GENERAL DESCRIPTION OF COLLIERY.

The Waratah Colliery is situate in the parish of Kahitah, in the County of Northumberland, New South Wales, and, approximately, in a south-westerly direction from the City and Port of Newcastle, and distant in a direct line 5½ miles. The property comprises an area of 2,660 acres (1,380 acres freehold and 1,280 leasehold from Government), which is bounded on the north by the New Lambton Colliery and the Scottish Australian Mining Company's Lambton Colliery, on a part of the west by the Australasian Colliery, partly on the south by the Scottish Australian Company's Ryhope Colliery, and on the east by the Burwood Colliery. The colliery is connected with Port Waratah (on the Hunter River), at which place the company's coal shoots are situate by a private railway, and with the Port of Newcastle by a private railway and the Government railway forming a junction at Hamilton. Some years since "Charles" Pit was sunk to the "Gully" seam at a depth of

267 feet. This seam was ultimately abandoned for a time, and the Government diamond drill engaged to bore at various sites on the estate. In all, five bores were put down. At a site—No. 2—some 20 chains south-west from the present Flaggy Creek shaft, the core showed the section of a good seam of coal, since identified as the celebrated "Bore-hole" seam, 7 feet thick. On this assurance, the Flaggy Creek shaft was sunk, and, on bottoming the seam, it was found that the drill had given correct indications. For reasons stated already in the description of the survey, it was resolved to drive a connection between the two shafts.

The coal, on being submitted to experts for examination, is pronounced to be a fine bituminous coal, and of excellent quality. The result of an analysis gives the following particulars:—

| | Per Cent. |
|---|---|
| Moisture ... ... ... ... | 1·72 |
| Volatile Hydro Carbon ... ... | 34·35 |
| Fixed Carbon ... ... ... | 59·12 |
| Ash ... ... ... ... | 4·40 |
| Sulphur ... ... ... ... | 0·41 |
| | 100·00 |

Coke, 63·52 per cent.

The seam is worked on the bord and pillar system, and is very little disturbed by faults, and has the full dip in the bord direction of 36 degs. south-west, and of about 1 in 50. Main and tail rope system of haulage is adopted, and the ventilation effected by means of a furnace. A pair of large direct-acting winding engines, by Walker Bros., Wigan, are being erected, and a large double Cameron's pump to drain the seam. Arrangements are now almost perfected for a large output of coal.

The PRESIDENT: I think Mr. Forster, Junior, has been in New South Wales, and may be able to add something to what is stated in the paper.

Mr. T. E. FORSTER: I do not think I can add anything. This was not one of the collieries I had the pleasure of seeing. It rather surprised me to hear it stated in the paper that the heading was driven at the rate of about 100 yards a fortnight.

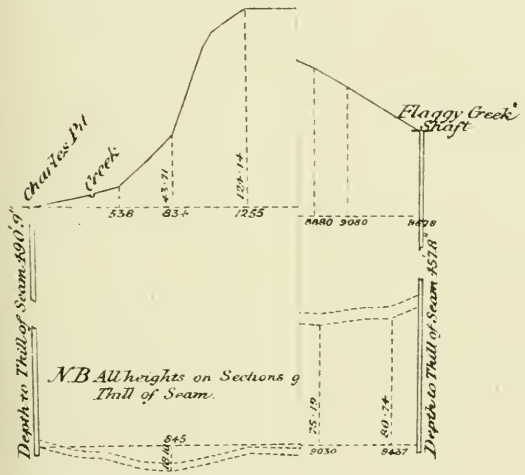
Mr. G. B. FORSTER: It is driven from both ends.

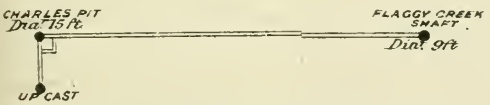
The PRESIDENT moved a vote of thanks to the writer of the paper.

Mr. G. B. FORSTER seconded the motion, and it was agreed to.

VOL. XXXVIII. PLATE I.

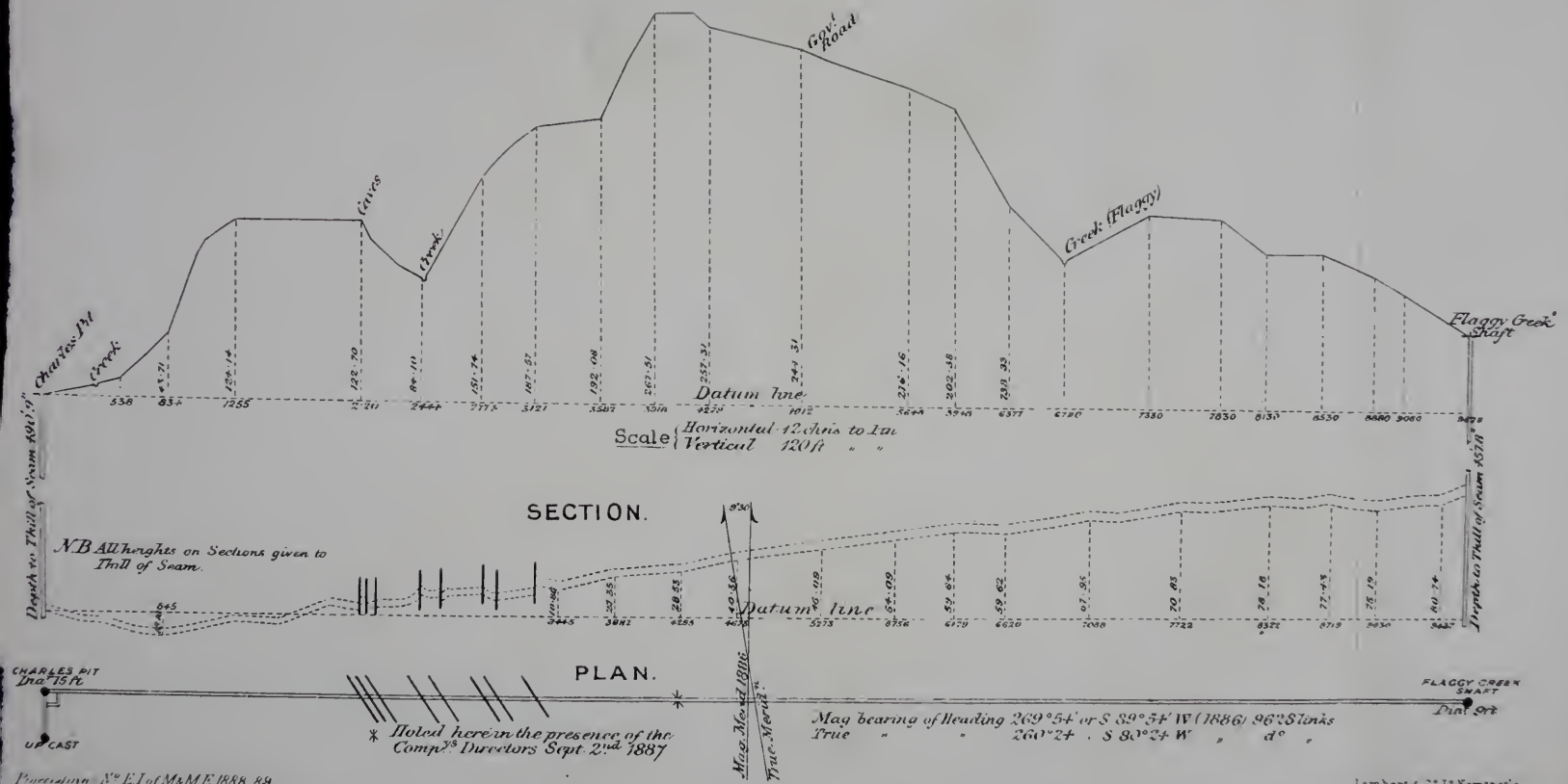
To illustrate Charles and Flaggy




Proceedings N° E I of M & M E 1888. 89 Lambert & C° L° Newcastle

*To illustrate Mr. James Hunter's paper On Description of Survey of Heading between the Charles and Flaggy Creek Pits, Waratah Colliery, New South Wales."*


Gov.t Road
Caves
Creek
Creek (Flaggy)
Charles Pit
Creek
Flaggy Creek Shaft
Datum line
Scale { Horizontal 12 chns to 1in
Vertical 120 ft " "
SECTION.
N.B All heights on Sections given to Mall of Seam.
Depth to Mall of Seam 1901'9"
Depth to Mall of Seam 1570'
Datum line
PLAN.
CHARLES PIT Dia 15 ft.
UP CAST
FLAGGY CREEK SHAFT
Dial 9ft
Mag. Merid 1886
True Merid.n
Held here in the presence of the Compy's Directors Sept. 2nd 1887
Mag bearing of Heading 269°54' or S 89°54' W (1886) 962 Slinks
True " " 260°24' . S 80°24' W " d° "

Proceedings No. E.I. of M. & M.E. 1888. 89

Lambert & Co.ª Lt.d Newcastle

The PRESIDENT: This being the first time I have had the honour of meeting the members since I was elected President of the Institute, I will take the opportunity of thanking you for conferring that honour upon me. I have promised that, at the December meeting, all being well, I will give you my inaugural address.

The PRESIDENT said that, according to the agenda, a new safety-lamp was to have been exhibited by Mr. Eli J. Palmer; but, owing to some miscarriage, the lamp had not come. Another gentleman, named Mr. Oswald Swete, was, however, present from the New Portable Electric Lamp and Power Syndicate Company, London, to show a lamp.

Mr. SWETE said the lamp he had now to exhibit was similar to the one which was shown at, he thought, the February meeting of the Institute by Urquahart and Nicholson. The lamp, in February, was in a rather primitive condition.

The PRESIDENT: Is this the same lamp?

Mr. SWETE: It is on the same principle, but more satisfactorily applied. The lamp that was shown before had an outer case of volcanite, which some members of the Institute thought was very tender, and might be easily broken. The lamp was now encased in birch wood, $\frac{3}{4}$-inch thick, which had been saturated in oil, and was capable of standing a great deal of knocking about. When the lamp was shown before, the light was on the top. That lamp had been tested at the Wigan Colliery Company's pits, and the miners did not like the light at the top, but preferred it at the front; and so now the lamp was designed with the light at the front part. The light was covered with toughened glass. It was the nature of toughened glass, when broken, to go into fine powder. If the glass in the lamp was broken, a lever immediately fell forward, and put out the light instantly. Mr. Rhodes, of Shireoaks Colliery, tested a dozen of these lamps by putting them into an iron tank containing a most explosive mixture of air and gas, and, setting a hammer swinging, smashed the front of the glass, and not one of the lamps exploded the gas. The weight of the lamp was $4\frac{1}{2}$ lbs. It would run 12 hours, for a week at a cost of 3d. per lamp per week. The first cost of the lamp was about £1. The miners so far liked this lamp very much, but thought there should be more glass in front, so as to give three-quarters of a circle light instead of a half-circle, so that they could see behind to their tubs.

Mr. G. B. FORSTER: What does it cost to keep up the lamp?

Mr. SWETE: 3d. per week, running 6 days per week, and 12 hours per day, including all repairs, interest on plant, depreciation on machinery, and renewals of incandescent lamps when necessary.

Mr. G. B. FORSTER: You have no attachment to the lamp for indicating the presence of gas.

Mr. SWETE: No.

Mr. G. B. FORSTER: Such an indicator is a *sine qua non.*

Mr. SWETE: Some say it is not, and others say it will be preferable. It is a difficult problem. We have been trying for a year, but have not succeeded yet. We hope to succeed in getting such an indicator.

Mr. G. B. FORSTER: You could have an independent indicator.

Mr. SWETE: Yes; but we wish to have some attachment to the lamp itself.

Mr. W. N. ATKINSON: Is the battery primary or secondary?

Mr. SWETE: Secondary. 130 lamps can be charged by a dynamo machine costing about £20—what is known as a one-unit dynamo. Any number of lamps could be connected together.

A MEMBER: What light does your lamp give?

Mr. SWETE; One-candle power. Mr. Steavenson saw the lamp lighted last night, and tested it against an oil safety-lamp, and found that this electric lamp gave considerably more light than the oil lamp.

Mr. C. C. LEACH: On what number of lamps do you calculate the cost at 3d. per lamp per week?

Mr. SWETE: It is estimated on 130 lamps. A one-unit dynamo charges 130 lamps. The cost is 3d. per lamp per week, running 12 hours a day for 6 days.

Mr. LEACH: How long does it take to charge them.

Mr. SWETE: Five hours.

Mr. T. E. FORSTER: What do you calculate is the life of a lamp?

Mr. SWETE: 1,000 hours, I think, is a safe average limit. That is the basis we calculate upon.

Mr. WALTON BROWN: How long will the battery last?

Mr. SWETE: So far as we have tested we have had lamps running daily, charged and re-charged, and the battery seems to give out a longer period of life now than when first started.

The PRESIDENT: Have you any of these lamps in use by officials at any colliery.

Mr. SWETE: Not at present. They were being tested at Crox-

dale and Tudhoe collieries for the last few days. Previous to that I had them at Shireoaks, and previously for four months at Wigan. So far, no lamps have been made for sale.

The PRESIDENT: Four months at Wigan, day by day?

Mr. SWETE: Yes; the same hewers had them in their own hands working coal.

The PRESIDENT: At what collieries?

Mr. SWETE: Under Mr. Daker's, at Croxdale; Mr. Johnson, at Tudhoe; Messrs. Hewlett and Webster, of the Wigan Coal and Iron Company; Mr. Knowles, of Pearson and Knowles; and at Shireoaks.

The PRESIDENT: During the four months have the lamps been worked regularly without impediment?

Mr. SWETE: No. During the four months, we had first of all the primitive lamp you saw, I think, in February; and now this lamp has improvements, which were suggested to us from seeing the work. The lamp now shown is the one used last.

The PRESIDENT: What is the longest period one lamp has been used?

Mr. SWETE: The longest period is one month, with this pattern of lamp.

Mr. G. B. FORSTER said he had great pleasure in proposing a vote of thanks to Mr. Swete for exhibiting the lamp. The exhibition of all electric lamps must be of interest to them; and the lamp Mr. Swete had now shown seemed to be a step in the right direction, especially as to the original cost, and the cost per week. They would hardly be content with a one-candle light; but, perhaps, Mr. Swete could make the light 2-candle power at very little extra cost. There must be some apparatus for the purpose of detecting gas. The electric light, without that, would be hardly safe in a gassy mine. It was satisfactory to know that people were working to try to perfect the electric lamps, and they might hope they would get the lamps to such a point that they might eventually be adopted.

Mr. STEAVENSON seconded the vote of thanks.

The vote of thanks was passed, and the meeting concluded.

On the 8th November, on the invitation of the promoters of the exploration, the Institute paid a visit to a most interesting boring at Seaton Carew. The following notes were kindly contributed for the information of the members by Mr. W. J. Bird.

## NOTES ON THE SEATON CAREW BORING.

By W. J. BIRD, M.E., A.Sc.

The Seaton Carew boring was projected by the late Mr. G. T. Pearson, of West Hartlepool, and has been carried out by Mr. C. T. Casebourne, C.E., and Mr. W. J. Bird, M.E. Adjacent landowners and the lessor have liberally assisted in this important exploration.

It was soon found that the salt bed did not exist here, and the magnesian limestone was reached at 522 feet, and continued to 1,400 feet, showing a thickness of 878 feet, the greatest hitherto recorded. From the base of the magnesian limestone the boring has pierced carboniferous strata, the exact geological position of which is uncertain, and is being continued to determine whether workable coal seams exist or not at this place.

The following is the Boring Section, with Notes up to 1,800 feet depth :—

### BORING SECTION AT SEATON CAREW.

Bored with Diamond Drill by Mr. Vivian, for Messrs. Casebourne and Bird.

| No. | Strata. | Ft. | In. | Ft. | In. |
|---|---|---|---|---|---|
| 1 | Brown Clay | 6 | 0 | 6 | 0 |
| 2 | Red Clay | 6 | 0 | 12 | 0 |
| 3 | Red Pinnel and Cobbles | 6 | 0 | 18 | 0 |
| 4 | Soft Red Sandy Marl | 12 | 0 | 30 | 0 |
| 5 | Red Sandy Marl | 3 | 0 | 33 | 0 |
| 6 | Red and Grey Sandstone | 7 | 0 | 40 | 0 |
| 7 | Red Marl | 2 | 0 | 42 | 0 |

| No. | Strata. | Ft. | In. | Ft. | In. |
|---|---|---|---|---|---|
| 8 | Grey Sandstone | 5 | 0 | 47 | 0 |
| 9 | Red Marl with Beds of Sandstone | 10 | 0 | 57 | 0 |
| 10 | Red Sandstone | 20 | 0 | 77 | 0 |
| 11 | Grey Sandstone | 2 | 0 | 79 | 0 |
| 12 | Red Sandstone | 13 | 0 | 92 | 0 |
| 13 | Grey Sandstone | 1 | 0 | 93 | 0 |
| 14 | Red Sandy Marl | 47 | 0 | 140 | 0 |
| 15 | Red and Grey Sandstone | 10 | 0 | 150 | 0 |
| 16 | Red Marl | 15 | 0 | 165 | 0 |
| 17 | Red Marl, with Beds of Grey and Red Sandstone | 8 | 0 | 173 | 0 |
| 18 | Red Marl, with Blue Joints | 35 | 0 | 208 | 0 |
| 19 | Red Marl, with Beds of Grey Sandstone | 24 | 0 | 232 | 0 |
| 20 | Red Marl, with Beds of Grey Marl | 33 | 0 | 265 | 0 |
| 21 | Red Marl, with Blue Joints | 24 | 0 | 289 | 0 |
| 22 | Red Marl, with Blue Joints and Veins of Gypsum | 171 | 0 | 460 | 0 |
| 23 | Red Marl and Veins of Gypsum | 7 | 5 | 467 | 5 |
| 24 | Anhydrite | 13 | 0 | 480 | 5 |
| 25 | Blue Marl and Veins of Gypsum | 3 | 0 | 483 | 5 |
| 26 | Anhydrite | 1 | 0 | 484 | 5 |
| 27 | Red Marl and Veins of Gypsum ("Rotten Marl") | 10 | 0 | 494 | 5 |
| 28 | Dark Marl and Gypsum mixed | 2 | 7 | 497 | 0 |
| 29 | Anhydrite, with Black Joints | 25 | 0 | 522 | 0 |
| 30 | Magnesian Limestone, with Spots of Gypsum | 27 | 0 | 549 | 0 |
| 31 | Light Grey Magnesian Limestone, with Spots and Veins of Gypsum | 38 | 0 | 587 | 0 |
| 32 | Dark Grey Limestone, with Spots and Veins of Gypsum | 16 | 0 | 603 | 0 |
| 33 | Dark Blue Shale | 3 | 0 | 606 | 0 |
| 34 | Anhydrite, with Beds of Dark Blue Shale and Gypsum | 35 | 0 | 641 | 0 |
| 35 | Light Grey Limestone and Gypsum | 7 | 0 | 648 | 0 |
| 36 | Blue Shale | 2 | 0 | 650 | 0 |
| 37 | Light Grey Limestone | 11 | 0 | 661 | 0 |
| 38 | White Limestone | 90 | 0 | 751 | 0 |
| 39 | Hard White Limestone and Gypsum | 12 | 0 | 763 | 0 |
| 40 | Dark Grey Limestone and Anhydrite | 20 | 0 | 783 | 0 |
| 41 | Light Grey Limestone and Gypsum | 18 | 0 | 801 | 0 |
| 42 | Light Grey Limestone | 29 | 0 | 830 | 0 |
| 43 | Limestone and Gypsum mixed | 31 | 0 | 861 | 0 |
| 44 | Grey Limestone and Gypsum | 11 | 0 | 872 | 0 |
| 45 | Light Grey Limestone and Gypsum | 33 | 0 | 905 | 0 |
| 46 | Light Grey Limestone | 50 | 0 | 955 | 0 |
| 47 | Light Grey Limestone, with Spots of Gypsum | 45 | 0 | 1000 | 0 |
| 48 | White Limestone | 107 | 0 | 1107 | 0 |
| 49 | Light Grey Limestone | 23 | 0 | 1130 | 0 |
| 50 | Broken Light Grey Limestone | 23 | 0 | 1153 | 0 |
| 51 | Light Grey Limestone | 9 | 0 | 1162 | 0 |
| 52 | Light Grey Limestone, with Spar Cavities | 9 | 0 | 1171 | 0 |
| 53 | Light Grey Limestone | 7 | 0 | 1178 | 0 |
| 54 | White Limestone | 82 | 0 | 1260 | 0 |
| 55 | Light Grey Limestone, with a little Gypsum | 23 | 0 | 1283 | 0 |
| 56 | Dark Grey Limestone, with Gypsum | 17 | 6 | 1300 | 6 |
| 57 | Dark Grey Limestone, with Veins of Gypsum | 19 | 6 | 1320 | 0 |

| No. | Strata. | Ft. | In. | Ft. | In. |
|---|---|---|---|---|---|
| 58 | Dark Grey Limestone, with Spots of Gypsum ... ... | 40 | 0 | 1360 | 0 |
| 59 | Light Grey Limestone ... .. ... ... ... | 40 | 0 | 1400 | 0 |
| 60 | Dark Grey Shaly Sandstone ... ... ... ... | 10 | 0 | 1410 | 0 |
| 61 | Red and Grey Shaly Sandstone ... ... ... ... | 17 | 6 | 1427 | 6 |
| 62 | Black Shale ... ... ... ... ... ... ... | 0 | 6 | 1428 | 0 |
| 63 | Dark Grey Shale ... ... ... ... ... ... | 1 | 0 | 1429 | 0 |
| 64 | Dark Grey Sandstone... ... ... ... ... ... | 1 | 0 | 1430 | 0 |
| 65 | Grey Sandstone, with Black Joints ... ... ... | 30 | 0 | 1460 | 0 |
| 66 | Grey Sandstone ... ... ... ... ... ... | 10 | 0 | 1470 | 0 |
| 67 | Very Coarse Grey Sandstone ... ... ... ... | 15 | 0 | 1485 | 0 |
| 68 | Dark Grey Sandstone... ... ... ... ... ... | 0 | 6 | 1485 | 6 |
| 69 | Black Shale ... ... ... ... ... ... ... | 0 | 6 | 1486 | 0 |
| 70 | Red and Grey Sandstone ... ... ... ... ... | 1 | 7 | 1487 | 7 |
| 71 | Black Shale ... ... ... ... ... ... ... | 12 | 4 | 1499 | 11 |
| 72 | Dark Shaly Sandstone ... ... ... ... ... | 2 | 6 | 1502 | 5 |
| 73 | Black Shale ... ... ... ... ... ... ... | 10 | 0 | 1512 | 5 |
| 74 | Grey Sandstone ... ... ... ... ... ... | 4 | 0 | 1516 | 5 |
| 75 | Dark Grey Sandy Shale ... ... ... ... ... | 0 | 7 | 1517 | 0 |
| 76 | Coal ... ... ... ... ... ... ... ... | 0 | 10 | 1517 | 10 |
| 77 | Dark Brown Fire-clay ... ... ... ... ... | 1 | 2 | 1519 | 0 |
| 78 | Black Sandy Shale ... ... ... ... ... ... | 2 | 8 | 1521 | 8 |
| 79 | Dark Grey Sandy Shale ... ... ... ... ... | 1 | 8 | 1523 | 4 |
| 80 | White Sandstone ... ... ... ... ... ... | 26 | 8 | 1550 | 0 |
| 81 | Dark Grey Sandstone... ... ... ... ... ... | 5 | 0 | 1555 | 0 |
| 82 | Light Grey Sandstone ... ... ... ... ... | 12 | 8 | 1567 | 8 |
| 83 | Dark Shaly Sandstone, with *Coal* Joints ... ... ... | 1 | 4 | 1569 | 0 |
| 84 | Black Shale ... ... ... ... ... ... ... | 9 | 6 | 1578 | 6 |
| 85 | Coal ... ... ... ... ... ... ... ... | 1 | 2 | 1579 | 8 |
| 86 | Dark Blue Shale ... ... ... ... ... ... | 0 | 4 | 1580 | 0 |
| 87 | White Sandstone ... ... ... ... ... ... | 3 | 6 | 1583 | 6 |
| 88 | Grey Sandstone ... ... ... ... ... ... | 2 | 6 | 1586 | 0 |
| 89 | Black Shale ... ... .. ... ... ... ... | 8 | 0 | 1594 | 0 |
| 90 | Dark Grey Sandstone... ... ... .. ... ... | 9 | 6 | 1603 | 6 |
| 91 | Black Shale ... ... ... ... ... ... ... | 7 | 0 | 1610 | 6 |
| 92 | Black Shale, with beds of Dark Grey Sandstone... ... | 6 | 6 | 1617 | 0 |
| 93 | Black Shale ... ... ... ... ... ... ... | 6 | 0 | 1623 | 0 |
| 94 | Black Shale, with beds of Grey Sandstone ... ... | 7 | 11 | 1630 | 11 |
| 95 | *Coal* and Shale... ... ... ... ... ... ... | 0 | 1 | 1631 | 0 |
| 96 | Dark Brown Fire-clay ... ... .. ... ... | 2 | 0 | 1633 | 0 |
| 97 | Dark Grey Sandstone... ... ... ... ... ... | 6 | 0 | 1639 | 0 |
| 98 | Dark Shaly Sandstone ... ... ... ... ... | 5 | 0 | 1644 | 0 |
| 99 | Yellowish Sandstone ... ... .. ... ... ... | 8 | 9 | 1652 | 9 |
| 100 | Coarse Light Grey Sandstone ... .. ... ... | 16 | 6 | 1669 | 3 |
| 101 | Hard Yellowish Sandstone, with Lime Veinule ... ... | 2 | 3 | 1671 | 6 |
| 102 | Coarse Light Grey Sandstone ... ... ... ... | 3 | 6 | 1675 | 0 |
| 103 | Coarse Grey Sandstone ... ... ... ... ... | 1 | 6 | 1676 | 6 |
| 104 | Dark Grey Shaly Sandstone ... ... ... ... | 1 | 6 | 1678 | 0 |
| 105 | Black Shale ... ... ... ... ... ... ... | 8 | 0 | 1686 | 0 |
| 106 | Dark Grey Sandy Shale ... ... ... ... ... | 3 | 0 | 1689 | 0 |
| 107 | Dark Blue Shale .. ... ... ... ... ... | 7 | 0 | 1696 | 0 |
| 108 | Black Shale ... ... ... ... ... ... ... | 4 | 0 | 1700 | 0 |

| No. | Strata. | Ft. | In. | Ft. | In. |
|---|---|---|---|---|---|
| 109 | Dark Brown Shale ... ... ... ... ... ... | 3 | 0 | ... 1703 | 0 |
| 110 | Grey Shaly Sandstone ... ... ... ... .. | 10 | 0 | ... 1713 | 0 |
| 111 | Coarse Grey Sandstone, with *Coal* Scars ... ... ... | 24 | 0 | ... 1737 | 0 |
| 112 | Dark Grey Shaly Sandstone ... ... ... ... | 5 | 0 | ... 1742 | 0 |
| 113 | Yellowish Shaly Sandstone ... ... ... ... ... | 6 | 0 | ... 1758 | 0 |
| 114 | Dark Shaly Sandstone ... ... ... ... ... | 8 | 0 | ... 1756 | 0 |
| 115 | Black Shale ... ... ... ... ... ... .. | 24 | 0 | ... 1780 | 0 |
| 116 | Grey Sandstone, with beds of Black Shale ... ... | 10 | 0 | ... 1790 | 0 |
| 117 | Coarse Grey Sandstone, with Black Joints ... ... | 10 | 0 | ... 1880 | 0 |

## NOTES ON BORING SECTION.

No.

27 This "Rotten Marl" Bed is the usual cover of the Rock Salt Bed of South Durham.

30 Limestone containing 42·35 per cent. Carb. of Magnesia.

33 From this "Dark Blue Shale" there was a slight feeder of Rock Oil, and a strong feeder of Sulphur Water similar to the Croft Spa Water and which overflowed at the surface when work was suspended for a time.

38 Limestone containing 44·40 per cent. Carb. of Magnesia.

50 This Bed yielded a feeder of Saturated Brine which is still flowing.

58 At 1,340 feet the hole was contracted from 6 inches diameter to 4½ inches diameter.

59 Base of the Magnesian Limestone.

62 Coal Measures supposed to commence.

67 This Coarse Sandstone has a very close resemblance to the Northumberland 70 fathom post.

87 Fire-clay is mixed with this White Sandstone.

101 Tested by Hydrochloric Acid.

111 Very soft and Friable Stone.

To give an idea of the strata in the neighbourhood, Table I. has been drawn up. The rocks are classified as

(1) Surface Deposits.
(2) Upper Gypseous Marls.
(3) Red Sandstones and Marls.
(4) Lower Gypseous Marls.
(5) Saliferous Beds (Anhydrite, Salt, &c.)
(6) Magnesian Limestone.

No other borehole except Seaton Carew has pierced the entire series of the magnesian limestone.

The Table contains a summary of 23 borings in the district.

## ABSTRACT OF BORING SECTIONS.

| Situation of Boreholes. | Surface Deposits. | | Upper Gypseous Marls. | | Red Sandstones and Marls. | | Lower Gypseous Marls. | | Saliferous Beds, Anhydrite and Salt. | | Thickness of Salt referred to in preceding column. | | | | | | Magnesian Limestone. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Pure. | | Mixed. | | Total. | | | |
| | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | Ft. In. | | Ft. In. | | Ft. In. | | Ft. In. | |
| Hartlepool Cement Works ... | 97 0 | 97 0 | ... | ... | ... | ... | ... | ... | 267 0 | 364 0 | ... | | ... | | ... | | 38 0 | |
| West Hartlepool Cellulose Works | 53 0 | 53 0 | ... | ... | ... | ... | ... | ... | ... | ... | ... | | ... | | ... | | 184 0 | |
| West Hartlepool Cement Works | 30 0 | 30 0 | ... | ... | 355 0 | 385 0 | 220 6 | 605 6 | 108 10 | 714 4 | ... | | ... | | ... | | 55 8 | |
| Seaton Carew (Casebourne and Bird) ... ... ... | 33 0 | 33 0 | ... | ... | 256 0 | 289 0 | 194 5 | 483 5 | 38 7 | 522 0 | ... | | ... | | ... | | 878 0 | |
| Oughton ... ... ... ... | 119 0 | 119 0 | ... | ... | (?) | 527 11 | ... | ... | ... | ... | ... | | ... | | ... | | ... | |
| Greatham, Marsh House (Greatham Salt Co.) ... ... | 71 11 | 71 11 | ... | ... | 587 6 | 659 5 | 203 7 | 863 0 | 109 9 | ... | 68 | 6 | 14 | 3 | 82 | 9 | ... | |
| Cowpon Marsh (Newcastle Chemical Co.) No. 1 ... | 87 0 | 87 0 | ... | ... | 694 0 | 781 0 | 279 0 | 1060 0 | 154 0 | ... | 112 | 9 | 4 | 0 | 116 | 9 | ... | |
| Do. do. No. 2... | 77 9 | 77 9 | ... | ... | 755 3 | 833 0 | 223 0 | 1056 0 | 156 6 | ... | 115 | 4 | ... | | 115 | 4 | ... | |
| Do. do. No. 3... | 75 0 | 75 0 | ... | ... | 757 0 | 832 0 | 226 0 | 1058 0 | 147 0 | ... | 101 | 6 | 9 | 6 | 111 | 0 | ... | |
| Do. do. No. 4... | 78 8 | 78 8 | ... | ... | 761 10 | 840 6 | 220 6 | 1061 0 | 153 0 | ... | 90 | 6 | 28 | 8 | 119 | 2 | ... | |
| Haverton Hill Salt Co., No. 1... | 62 9 | 62 9 | ... | ... | 588 10 | 651 7 | 195 2 | 846 9 | 159 7 | ... | 95 | 4 | 27 | 6 | 122 | 10 | ... | |
| Do. do. No. 4... | 69 0 | 69 0 | ... | ... | 580 4 | 649 4 | 140 6 | 789 10 | 135 0 | ... | 104 | 6 | ... | | 104 | 6 | ... | |
| Westfield, Haverton Hill ... | 64 8 | 64 8 | ... | ... | 492 10 | 557 6 | 216 6 | 774 0 | 135 2 | ... | 94 | 9 | 8 | 6 | 103 | 3 | ... | |
| Sandfield, do. ... | 70 4 | 70 4 | ... | ... | 514 9 | 585 1 | 185 5 | 770 6 | 130 6 | ... | 87 | 10 | 5 | 8 | 93 | 6 | ... | |
| Stone Marsh, do. ... | 104 9 | 104 9 | ... | ... | 497 0 | 601 9 | 154 3 | 756 0 | 65 9 | 821 9 | ... | | 9 | 0 | 9 | 0 | 179 3 | |
| Newcastle Chemical Co., Port Clarence ... ... | 99 0 | 99 0 | 110 0 | 209 9 | 794 3 | 904 0 | 149 6 | 1053 6 | 39 6 | 1093 0 | ... | | ... | | ... | | 97 6 | |
| Tennant and Co., Haverton Hill | 83 3 | 83 3 | ... | ... | 610 9 | 694 0 | 201 3 | 895 3 | 118 11 | ... | 72 | 11 | 6 | 0 | 78 | 11 | ... | |
| Bell Bros., Trial Hole ... ... | 77 0 | 77 0 | ... | ... | 846 0 | 923 0 | 179 0 | 1102 0 | 159 0 | 1261 0 | 89 | 5 | 27 | 0 | 116 | 5 | 94 0 | |
| Bell Bros., No. 1 Hole ... ... | 96 0 | 96 0 | ... | ... | 694 0 | 790 0 | 214 0 | 1004 0 | 116 0 | ... | 65 | 0 | 12 | 0 | 77 | 0 | ... | |
| Middlesbro' (Bolckow & Vaughan) | 70 0 | 70 0 | 86 0 | 156 0 | 902 6 | 1058 6 | 132 8 | 1191 2 | 114 10 | 1306 0 | 100 | 0 | ... | | 100 | 0 | 7 4 | |
| North Ormesby, Middlesbro' ... | 34 0 | 34 0 | 242 0 | 276 6 | 859 6 | 1136 0 | 182 9 | 1318 9 | 121 3 | ... | 89 | 1 | ... | | 89 | 1 | ... | |
| Imperial Iron Works, Middlesbro | 66 6 | 66 6 | 149 10 | 216 4 | 1117 2 | 1333 6 | 203 6 | 1536 9 | 155 3 | ... | ... | | ... | | 86 | 5 | ... | |
| South Bank, Eston (Bolckow & Vaughan) ... ... | 41 0 | 41 0 | 453 0 | 494 0 | 836 6 | 1330 6 | 200 6 | 1531 0 | 148 8½ | ... | 81 | 0 | 1 | 6 | 82 | 6 | ... | |

NORTH OF ENGLAND INSTITUTE

OF

# MINING & MECHANICAL ENGINEERS

GENERAL MEETING, SATURDAY, DECEMBER 8TH, 1888.

Mr. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting. The following gentlemen were elected:—

ASSOCIATE MEMBER—
Mr. J. I. HOPPER, Tyne Dock.

STUDENTS—
Mr. N. COCHRANE, Aldin Grange, Durham.
Mr. P. STANTON, Trimdon Grange.

Mr. JOHN MARLEY then read his Presidential Address :—

GENTLEMEN,—

BEFORE entering upon the main subjects of my address, I wish to acquit myself of the agreeable duty of thanking the Council and the individual members of this Institute for the honour they have conferred upon me by placing me in the presidential chair.

Whilst promising to do my utmost to promote the interests of this Institute, I invite the cordial assistance of all, as essential to success.

It is difficult to find any topic not already dealt with in previous inaugural addresses, more especially, as the ten presidents who have preceded me have all had the pleasure of calling attention to the continued success of this Institute, and of enumerating the advances that had taken place either during their own respective periods of office, or during the whole of the preceding years of the life of the Institute. The progress of science during the last fifty years, as applied to mining operations, is dealt with so exhaustively in the previous addresses that it may not be amiss for me, whilst touching lightly upon some of the things accomplished, to look to the work left undone. To point my meaning, I remind you of the words of your first President, the late Mr. Nicholas Wood, in his address in 1852:—"There is nothing so important, nothing so useful, when unsuccessful, than that we should have communicated to us the causes of failure." And, again, in his Birmingham address, in 1861, where he says: "It is also extremely desirable to know what has been left undone."

The recording of short-comings may be as useful, but is certainly not so pleasant as the other course. I, therefore, ask your forbearance.

There must be no "finality" in improvement! We must not rest on past laurels! Let your energies, therefore, be directed to subjects requiring further elucidation, and your efforts to those where improvement is still needed!

Lord Armstrong, in his address in 1873, urged economy in production and economy in consumption of coal. Whilst the former

may have received, and may still be receiving, close attention, I am afraid the question of getting fuller and more economical results in consumption continues to be more or less neglected. I venture to re-affirm Sir Lowthian Bell's recommendation that we should not direct all our attention to searching for substitutes for coal, but, on the contrary, to endeavouring to catch the 90 per cent. of power lost from the coal we use.

There is still much to be done in the substitution of machine for hand labour. The replacement of men by machinery underground would, in some cases, be a most important element in the reduction of accidents.

To indicate further where, I think, we have still much to do, I turn to the report of the Royal Coal Commission, dated July, 1871, the Commission having been appointed 28th June, 1866, the work of which was carried out by five committees, viz. :—

A. Committee on possible depths of working (14th May, 1870)
B. Committee on waste in combustion (9th June, 1871).
C. Committee on waste in working (4th May, 1870).
D. Geological Committee on the probability of finding coal under the Permian, New Red Sandstone and other superincumbent strata (dated 21st August, 1869, July 22nd, 1870, 27th May and 26th July, 1871).
E. Committee on mineral statistics, viz. :—Production, Consumption, Export (in 1871),

and also to the classification of the headings of the Royal Commission of 1879 on "Accidents in Mines," the preliminary report of which was issued in September, 1881, and the final report, dated 15th March, 1886, viz. :—

1. Method of working and ventilation.
2. Falls of roof and sides.
3. Spontaneous combustion.
4. Miscellaneous mine accidents.
5. Fire-damp.
6. Coal-dust.
7. Explosive agents and principal methods of using them with substitutes for explosive agents.
8. Lighting and safety lamps, with employment of the electric light.
9. Fire-damp indicators.
10. Shaft accidents.

11. Inundations.
12. Summary and recommendations.
13. Concluding observations.

And, having regard to the lapse of time since these enquiries began, I would venture to suggest that, without presumption, committees from your Council and members might be formed, which could, by short statements on the various headings or topics under each Commission, bring forward new facts, create discussion, and elicit much information, old and new, for the benefit of the members generally.

## LONGWALL SYSTEM.

The longwall system was strongly recommended 20 years ago by your then President, Sir George Elliot, and also by your past President, the late Mr. T. E. Forster, in his address in 1866, and, although this system has since come into much more frequent use, it, and the modifications of the same, might, in many instances with advantage, be still more fully adopted. The system is favourably noticed in the Royal Commission Report on Accidents.

## FANS.

The fans most generally approved are the Guibal, Schiele, and Waddle. Compressed air for fans placed "in-bye," although commended by Mr. Lindsay Wood when President in 1876, has not yet been brought into general use. I am pleased to give below an account of a practical test of the system at Ryhope Colliery, supplied to me by one of your members, Mr. W. F. Hall, and, in doing so, repeat Mr. Wood's recommendation.

Mr. Hall says:—"I have looked over the paragraph in Mr. "Lindsay Wood's presidential address (Vol. XXV., pages 195 and "196) to which you call my attention, where he says he hopes to see "compressed air as a motive power applied to 'driving ventilating "fans underground placed at long distances from the bottom of the "shaft,' as it is his opinion that it would give great assistance to the "general ventilating powers by relieving the resistance of the air in "travelling round these far-off splits," and so produce a total increase "of air.

"This idea has received a practical test at Ryhope Colliery. In "one of the far off districts, where the ventilation was not satisfac- "tory, I had a small experimental fan erected, using as a motive

"power the compressed air taken into the district for haulage "purposes. The advantage to the district was considerable, while a "gain was observable in the general ventilation of the mine; and I "am satisfied that districts which would otherwise be very difficult "to ventilate satisfactorily may by this means be kept in proper "working condition.

"From the results of this trial it is my intention to apply this "auxiliary ventilating power to the large area of under-sea coal we "are working at Ryhope Colliery as it becomes necessary."

Mr. J. Lancaster, for the Lesmahagow Coal Company, has been experimenting on underground and "in-bye" fans driven by compressed air, and is using, in one instance, a "blowing" fan Although the experiments are not yet completed, he is favourably inclined to the system. With fans "in-bye," the first fixing of regulators for each main air split may require special attention.

The position of the main ventilating fans, whether surface or underground, will now require consideration in regard to the third rule under 49 General Rule of the Mines Regulation Act, 1887, the "in-bye" or "helping up" fan, of course, requiring somewhat similar consideration.

## ELECTRICAL AND OTHER COAL-CUTTING MACHINES.

As bearing on accidents, coal-cutting by machinery is an important question, because of its effect on the number of men at the face of the workings. Mr. Lindsay Wood has done much to further the use of coal-cutting machines with the aid of compressed air; but more remains to be done.

The patent coal-cutting machine brought out by Stanley, of Nuneaton Colliery, which is said to have driven 21½ yards in twenty-four hours in a small tunnel, seems to merit attention.

Lord Armstrong, in his address nearly sixteen years ago, set forth the position of coal-cutting machines. His description of what was then wanted is equally applicable now. Can they be said to be much improved since then?

After I had written the last sentence an engineering friend urged me to see Messrs Bower and Co.'s electrical coal-cutting machine and electrical transmitters, and although your past president, Mr. John Daglish, in 1886 pointed out in his address several objections to electrical transmission, many of these have been surmounted, and others no doubt will be. I have, therefore, inspected the machinery,

and have pleasure in giving the following description, as a striking instance of the applicability of electric power in mines and collieries, and of its utility when the motor is to be moved about. This electric coal-cutting machinery is now being introduced by Messrs. W. T. Goolden and Co., of London, as licensees under the Patents of Messrs. Bower, Blackburn, and Mori, with further subsidiary Patents. The Messrs. Bower had for some years been experimenting on the use of coal-cutting machinery, and had arrived at last at a form of machine which gave most satisfactory results, except in so far that, unless near the source of power, great difficulty was experienced in obtaining the necessary motive power. At last electricity was tried, and although considerable modifications have had to be made in the original method of application, by attention to every detail, very satisfactory results are now obtainable. This machine is only now being put into the market, as the makers have been anxious to discover every fault, and overcome all difficulties practically before bringing it out seriously. The original machine was started in May, 1887, and is still running, doing very good work; although since then the machines have been completely remodelled and greatly strengthened. The machine consists of a frame travelling on wheels, carrying a specially designed electric motor, driving a shaft which carries the cutter attached by bolts to a coupling. This cutter consists of a bar carrying a series of star-shaped cutters, specially formed. The whole motor, and the shaft carrying the cutter bar, can be rotated in a horizontal plane, for the purpose of bringing the cutter in and out of the coal. The cutter is revolved by the electric motor at about 600 revolutions per minute, and the motor develops six to nine actual horse-power according to the hardness of the seam.

The method of operating is thus. The motor is started, the turntable is rotated by the worm wheel till the cutter has swept through a right angle, and is then 3 feet 6 inches deep in the coal. It is then drawn along the face by a winch, under or over-cutting the coal to that depth. The form of the cutter obviates the great difficulty usually met with in coal-cutters, viz., the jambing of the cutter by the falling coal, as in this case the cutter is always against the solid coal, and has never been known to be stopped when running by falling coal. The speed of cutting varies with the seam. These cutters have actually effected 45 yards per hour, including all stoppages, to put up props, &c., and in actual cutting time 30 yards have been cut in 36 minutes in hard dirt with pyrites and iron-

stone lumps. The advantages of the machine are obvious, the cutting can be carried on in any seam of dirt, thus saving coal. Only about 4 inches of coal is removed. The coal is cleaner, and in larger pieces. A smaller length of face is required for a given output of coal, thus reducing bye-work, &c. The power is brought from a dynamo at the surface by two thin cables, whose position can be altered in a few minutes, as they can be rolled up and run out and hung on hooks like a piece of cord.

Messrs. Bower's cost of holing by hand is about four times per yard more than by the machine. The difference in percentage of small is 10 per cent. in favour of the machine.

The dynamo producing the electric current is situate preferably at the surface, and the power is led down the shaft by two small cables. Where wet or foul air is met with, the lead-sheathed cables, manufactured by Messrs. J. Fowler and Co., Limited, of Leeds, have proved very useful, and give very satisfactory results. The cables are then led along the road, either on insulators or fixed on a wood casing to the roof, or put on the floor. The cable in use at the actual face is a double insulated cable, both wires in one covering, being more convenient for handling. This is attached at any point of the main cable by screw connectors. The actual average engine-power required at the surface will be from 10 to 20 horse-power, according to circumstances, but it is well to run the dynamo from an engine capable of supplying when necessary considerably more, and the motor will then devolop at times, for short intervals, more than three times its nominal power, enabling it to get through very hard pieces of stone or pyrites which occur in most seams.

The machines are very strongly built, and designed with a view to being handled by non-technical persons, and all wire on the machine is enclosed in metal casings to avoid mechanical damage, and where necessary the whole of the revolving armature, and collector and brushes, are enclosed in gas tight casings. In addition to the original machine working at Messrs. Bower's collieries, these gentlemen have recently put down two more sets, and the machinery will be under trial at the pits of Messrs. H. Briggs, Son, and Co., Normanton, and Messrs. Winn, Nostell, the latter part of this month.

A new machine is now being worked out, which, employing the same principle of cutting, is adapted for the cutting of headings, either circular, or square, or rectangular.

## BOILER EXPLOSIONS.

Curiously enough, boiler explosions are not mentioned in the report of the Royal Commission on Accidents. We have here a subject which presents much scope for investigation, but the causes of such disasters are neither sufficiently known nor understood.

In a paper on Steam Boiler Explosions, by one of your members Mr. Stephen C. Crone (Vol. XI. page 41), he alludes in the following terms to a lecture by the late Mr. Robert Hunt, F.R.S.: "Directing attention to the remarkable action of heat on water containing no air, and the spheroidal condition of the steam generated, two very active and predisposing causes of boiler explosions were to be found."

Whether the causes may be traced to an absence of air in the water, or, as has been too frequently insinuated, to want of water in the boilers, or to some other cause unknown, the question should be solved.

## "COLLIERY WARNINGS."

The Royal Commission on Accidents say that they "entertain great doubt as to the wisdom of placing reliance on the issue of meteorological warnings. These can at best only convey very imperfect information, which moreover may be sometimes dangerously misleading." One naturally feels a disinclination even to appear to discourage anything that it is alleged will help to prevent accidents, but as I think these warnings misleading, I can only endorse the views expressed by Mr. G. B. Forster in his presidential address, and I would recommend, for your consideration, Mr. V. W. Corbett's statistics and experiments after the Seaham Colliery explosion (Vol. XXXII.—225) in a paper read at Barrow-in-Furness in July, 1883. Some of the instances given show the barometer to have been 34 hours behind the water gauge in indicating, and in other cases 23 hours and 9 hours behind. The last-named gentleman has lately shown me some further diagrams for 1887, which corroborate those of 1883. Members, where possible, should establish similar readings and tests, and generally prosecute the study of this branch of observation.

If we wait for these "warnings" *before we act,* I am afraid we shall find ourselves a day too late.

### COAL-DUST.

Professor Bedson's last paper on his recent experiments on "Coal-Dust" seems to me to have considerably advanced the solution of this vexed question. He practically proves that coal-dust contains our opponent as one of its constituents, but whether as an originating, or only as an intensifying explosive agent, remains more or less an open question. For myself, I can, as yet, only regard it as an assisting and intensifying agent.

### EXPLOSIVE AGENTS.

Sir George Elliot was an early advocate of the disuse of gunpowder as an explosive agent. In his address, in 1868, he speaks of having urged its abolition twenty years before (1848). Since then there has been a wonderful change in the laws and practices affecting its use. Mr. G. B. Forster, when President, fairly urged that the use of gunpowder should not be indiscriminately forbidden.

Boring and drilling appliances, as substitutes for explosives, affect the question. The Diamond rock drill machines, so far as obtaining geological results with accuracy are concerned, have practically arrived at perfection. For speed, as shown in the boring of the salt wells in South Durham, the American boring engine and machinery have proved themselves formidable competitors, having bored 5 feet per hour, and at an average of 63 feet *per diem*.

Messrs. A. L. Steavenson's and W. Walker's drill machines have done good service in Cleveland ironstone mining, and stand well in the front rank.

### Mr. A. L. STEAVENSON'S HYDRAULIC DRILL IN CLEVELAND.

This machine has already been described in the Proceedings of this Institute (see Vol. XXXVI). Its continued use since it was described has given much satisfaction, the average weekly output amounting to (180 tons per shift of eight hours or) 1,080 tons per week. This quantity represents between 60 and 70 holes per shift of an average depth of about 4 feet 3 inches. The water used is from behind the Tubbing, and conveyed in-bye in pipes, the exhaust water running home to the pumping shaft.

### "RAMSAY WEDGE."

This invention has for its object the getting of coal where powder is not permitted or is undesirable. It also gets the coal in a larger

and sounder state, so that the quantity of round coal is improved. It has now been in operation about two years at Tursdale; they are getting about 3,000 tons a fortnight very successfully, and the wedge is also working at several other places.

## SAFETY LAMPS.

Since your first President said in 1861 "that a well made gauze lamp is quite safe in all ordinary cases" there have been, not only many improvements, but the standard of lamp required has also been much advanced. The condemnation of the unprotected Davy, Clanny, and Stephenson lamps by the Royal Commission was an important step.

Much has yet to be done before we have a lamp really perfect under all conditions, and, although electric lamps have made rapid progress, we are still awaiting the lamp *of the future.*

## SAFETY HOOKS.

Although safety hooks with steam brakes have practically accomplished what was intended, safety cages and catches are not yet considered absolutely reliable, and they offer scope for further experiments and attention.

## TRANSMISSION OF POWER.

A very important factor in effective mining is the transmission of motive power. Professor Ayrton in his valuable lecture on the "Electric Transmission of Power," delivered at the meeting of the British Association at Bath, in September last, asked, what is power and why do we want to transmit it? A practical answer would be that it is a means, for instance, of pumping water, of driving fans, of haulage underground, and that we want to transmit it long distances underground to carry out these objects. I would venture to urge the younger members (more especially) to peruse and study this paper of Professor Ayrton's.

Transmission of power, whether by steam, compressed air, hydraulics, ropes in various ways, electricity, gas engines, or otherwise, constitutes one of the most important subjects for future consideration.

Professor Ayrton advocates electricity,

1st.—For economy in fuel.

2nd.—Because it is easily controlled.

3rd.—Because of the ease with which it can be conveyed to its work, or *vice versa*.

4th.—Because of its cleanliness.

5th.—Because it may be used alternately for power or light.

We have a good example of the concentration and transmission of power in the Birmingham Compressed Air Company (under Act of Parliament), working with air to a pressure of four atmospheres at a central station.

It has been ascertained by them, from the record of facts in a certain defined district, that the best steam engines only used during the day one-third of their maximum power, others using only one-seventh each, of course, having plant complete for the maximum power.

With the central arrangement, separate engines only are required at each works, and boilers and chimneys only at the central establishment.

The North Staffordshire Mining and Mechanical Engineers visited this company's establishment last October.

The company's operations are spread over an area of $1\frac{1}{2}$ square miles, and will require 23 miles of mains to retail the compressed air to small consumers.

Mr. Lindsay Wood urged that further consideration should be given to the late Mr. W. N. Taylor's paper on compressed air (Vol. XXI.), 1872. I now endorse his recommendations.

As regards the transmission by ropes, we may consider the exhaustive and complete system of haulage exhibits at the Newcastle Exhibition last year—see preliminary report (Vol. XXXVI.)*—to be a considerable step in advance of the report of the Tail Rope Commission of 1865, which was issued in 1868, and was then a full and elaborate epitome.

Other systems worthy of being described, are:—

Lartigue: Centre rail.

Electric Motor: Driving spur gear to work friction pulleys or drums.

Telpherage (Electric motor) running on ropes (Ayrton and Perry).

Soda Locomotive: Honigmann.

* A more detailed report on these exhibits is under consideration.

Manilla Rope: Taken down pit to work drums, &c., underground.

Electric Locomotive:

Air haulage engines (for driving drums, friction pullies).

There is another good example of such transmission at Schaffhausen Falls, on the Rhine, by means of quick running ropes driven by turbines.

As an example of electric power, Messrs. Immisch and Co. give an instance of 120 gallons of water per minute being raised through 900 ft. at once by their electric motors, at St. John's Colliery, Normanton.

## GEOLOGICAL.

Whilst acknowledging the valuable services which your Secretary, Professor Lebour, and other members have already rendered in geological subjects, I would urge that continued attention should be given to such questions as the correlation of coal seams, the duration of our local coalfields, and coal-mining under the sea and elsewhere at great depths.

The recent visit (8th November last) of your members to Seaton Carew, the discussion on the possibility of the extension of the coalfield south from Wingate to Cleveland, and the geological information that is being supplied by the Diamond boring, now 1,814½ feet in depth down from the surface, might supply material for some further papers.

The late Mr. J. Buddle's "Synopsis of Coal Seams," prepared for the British Association in 1838, and the paper prepared in 1863 by the late Mr. N. Wood, the late Mr. J. Taylor and myself, again for the British Association, have been followed up by papers by your members, Mr J. B. Simpson and Mr. M. W. Brown, and I would suggest that further information on the subject should be given from time to time.

Sir Lowthian Bell lately read a paper on the "South Durham and Cleveland Salt," to the Institute of Civil Engineers, in London, and Mr. W. J. Bird, one of your members, so recently as June last, read a paper on the subject before the Geological Society of Manchester, but I cannot recall a paper given to this Institute since my own in 1863 (Vol. XIII.) on "Rock Salt at Middlesbrough." There is, therefore, another opening for information on this subject.

The salt has been proved over 12 square miles, or 7,680 acres. An acre is estimated to produce 200,000 tons of salt, or approximately the amount of the annual requirement of the Tyne.

According to the Government Inspector's report for 1887, the production of salt that year was 136,267 tons.

## COKE OVENS.

Besides the ordinary Beehive ovens, there are the Simon-Carvès,
The Jamieson oven,
Cochrane's,
Sir B. Samuelson's,
Coppée's,

And now Dr. Bauer's patent is receiving the attention of the coke manufacturers. In January next, coke will, it is expected, to be made by this patent at Carlton Iron Works.

In a valuable paper on the "Manufacture of Coke" (Vol. VIII., 1860) by Mr. A. L. Steavenson, the production of coke for Northumberland and Durham is given as 2,000,000 tons, and for Great Britain, 5,000,000 tons, whereas now Durham and Northumberland alone are estimated to produce 5,000,000 tons.

The following copy of an advertisement of 40 years ago refers to the first printed specification* for coke-making :—

COKE.

To be Let,

For the Term of One Year.

The Manufacturing of Coke (148 ovens), at Woodifield, near Crook. Specifications may be seen at the Woodifield Colliery Office, on Saturday, the 25th inst. ; and sealed Proposals will be received by Mr. John Marley, Viewer, Crook, up to Saturday, 9th December, 1848.

Woodifield Colliery Office. Nov. 22nd, 1848.

On the question of Government Inspection, I need only take the Government return for "Mining and Mineral Statistics," 1887. The following extract will show not only the increase in safety, but its continuous progression and advance :—

| | |
|---|---|
| For year 1851, first year Inspectors' Returns, ratio of persons employed to each death ... ... ... ... ... | 219 |
| 1st 10 years ending with 1860 ... ... ... ... ... | 245 |
| 2nd 10 ,, ,, 1870 ... ... ... ... ... | 300 |
| 3rd 10 ,, ,, 1880 ... ... ... ... ... | 425 |
| For the year 1887 ... ... ... ... ... ... ... | 529 |

Again, death-rate from accidents per 1,000 persons employed, average for 10 years ending with 1883, 2·238, with 155,793,844 tons per annum, or 446 employed per life lost.

* Can any member supply a copy of the above specification.

For 1887, the death-rate from accidents per 1,000 persons employed was 1·890, with 173,049,795 tons, or 529 per life lost, showing "that the coal miner's occupation is now fully twice as safe "as it was 30 years ago," as then it was 1 death in 245, and in 1887, 1 death in 529.

Again, under the Coal Mines Regulation Act, for the 10 years ending with 1883, there is an average of 1,127 lives lost to an average of 155,793,844 tons per annum, with the result of 1 death for 138,237 tons. For 1887 there are 995 lives lost to 173,049,795 tons, with the result of 1 death for 173,919 tons.

I am glad to note the northern counties stand well, viz., South Durham, with Westmoreland and the North Riding (for coal), 1 for 262,068; North Durham, Cumberland, and Northumberland, 1 for 225,455 tons.

Cleveland ironstone mining shows 1 for 415,035 tons.

Under the Coal Mines Regulation Act for 1887 we now have both "managers" and "under-managers." The definition of those eligible, if taken literally, is as follows:—"No person shall be "entitled to be a candidate unless he shall have had *practical* "*experience* in a mine for at least five years." Some have attempted to make this definition depend on the words "in a mine."

This appears to me, to be too literal, and to be deprecated not only as a discouragement to the Durham and other Colleges of Science, but because it ignores all scientific mining. What is the "*practical experience*" to be? In coal hewing, putting, surveying, or in *all* knowledge and practice necessary for the management of a mine?

I refer you to Vol. XVIII., page 34, for a definition of a mining engineer, showing what your (past) President, Mr. E. F. Boyd, laid down as an outline of what should be required of a mining engineer, and on the general subject of an engineer's training, education, and standing I would also refer you to a paper given at the Glasgow meeting by Professor John Young, M.D., of Glasgow, to the Shipbuilders' Institute of Engineers of Scotland. (See this Institute Vol. XXI., page 21.)

The DURHAM COLLEGE OF SCIENCE was opened on the 5th November last by Her Royal Highness Princess Louise.

Whilst claiming this College as the offspring of this Institute, and as one of our great objects practically accomplished, I take this opportunity of acknowledging much valuable assistance received by this Institute from the Professors of the College.

## LIBRARY.

The young members of the present day can scarcely realise their advantages in having this Library, with upwards of 5,000 volumes, besides the 37 volumes of the Institute's own Proceedings, which in themselves constitute collectively a grand collection of mining and engineering facts. In 1868 this Library contained only about 326 volumes. It now also contains the 6-inch ordnance maps of Northumberland and Durham, the whole of the published sheets of the 1-inch and 6-inch Geological Survey maps (with vertical and horizontal sections) of the United Kingdom, besides a number of geological maps of foreign countries. Compare this with the circumstances of 45 years ago, when I and my contemporaries, after *walking* six to ten miles into Newcastle, could only obtain access to the few volumes of the Natural History Society, which contained a very few papers on coal mining, namely, those by the late Mr. J. Buddle and the late Mr. N. Wood.

The want of a standard book on Coal Mining Engineering referred to by Mr. E. F. Boyd in his address on the occasion of the inauguration of the Wood Memorial Hall, is still felt. Your past President, Mr. G. C. Greenwell's work on "Mine Engineering" being one of the first.

I have frequently addressed myself especially to the young members. May I now add a word more by way of encouragement to them to ask questions, in order to create discussion, and elicit information; also, they should put on record all new observations and bring them before the meetings.

## FEDERATION OF THE VARIOUS MINING INSTITUTES.

Your first President, in his address, stated that this Institute was not intended to interfere with any of the London Institutes, there being then one spoken of for London. As bearing on this, I may mention that there are now about 40 of our members who are also members of the Institute of Civil Engineers in London, besides others who are members of other Institutes.

I find that at the meeting in London last June (see Vol. XXXVII.), Sir Lowthian Bell, in attributing the credit of first advocating the question of federation to Mr. Daglish, and Mr. Daglish in attributing it to Mr. Forster, had, like myself, missed the real originator, namely, Sir George Elliot, in his address in 1868 (see Vol. XVIII.). As there is now a report of the London meeting in the last volume (Vol. XXXVII.), I do not think

more need be said until the proposed meeting is held at Sheffield, in the next few weeks, at which the views your Council holds and the paper of your late lamented and indefatigable Secretary, Mr. T. W. Bunning, will be brought forward, and I trust some practical result will be arrived at.

A committee now at work, which is of a federative character, is the Fan Experiments Committee, from members of the South Wales, Midland, and North of England Institutes. The Flameless Explosives Committee and the Committee of Records of Earth Tremors are also of a similar character and cover subjects suitable for joint experiments.

## FINANCE.

Your first President expressed fears on the question of ways and means. His estimate was that the Institute would have 100 members (in fact it had only 80) at £2 2s., or £210 per annum revenue, with an annual expenditure of not less than £400 or £500.

For the year ending August, 1888, we had upwards of 700 members of all classes, and an income of near £1,600.

This Institute has rendered services to the lessors and lessees of collieries and mines, the pecuniary value of which services is simply incalculable, and I would suggest that a special appeal should be made for their support. Every colliery, mine, and railway should be represented in your list of members. Special provision has been made under Rule IX. to benefit the staff of such mine-owners, by the low subscription of £2 2s. per annum, but hitherto from mineowners, as a body, the Institute has not received much support. They do not seem to recognise that the object of the Institute is the prevention of accidents, and the advancement of the science of mining and engineering generally.

## RULES

### THE PRESIDENT, VICE-PRESIDENTS, AND MEMBERS.

Under the rules, which were signed by the Home Secretary on the 2nd July, 1877, the Royal Charter having been obtained on November 28th, 1876, the President's term of office is not to exceed in any case a consecutive term of three years. This period has never been exceeded except in the case of the first President (before this rule was made). The third President, Sir Geo. Elliot, only

held office one year (1868-9), and notwithstanding the bye-laws passed in 1884 in favour of a two years tenure of office which have been observed by the last two Presidents, I think that Sir Geo. Elliot's example of holding office for only one year may occasionally be followed with advantage. It would make the office and honour more often available for a greater number of those well qualified.

In the Royal Charter it was established that all past Presidents should become *ex-officio* members of the Council, so long as they continue members of the Institute. You thus now have eight useful ex-Presidents *ex-officio* members of the Council, which they strengthen in special and ordinary cases.

In 1883-4 I endeavoured to get a similar provision carried as affecting the Vice-Presidents, but its adoption was deferred.

I think the time has arrived when such a bye-law would be a salutary regulation. It would more frequently place the honourable position of Vice-President at your disposal as a recognition of the lengthy services of ordinary members of the Council, and would have a tendency to retain the interest and services of many useful members by their election on to the Council.

The rule could be made to apply either to *all* past Vice-Presidents or only to those who had held office for a consecutive term of years. If for three consecutive years, there would now be nine *ex-officio* Vice-Presidents, besides the three who have been one, one, and two years respectively in office.

## TRIVIAL POINTS.

We have recently elsewhere had addresses on "nothing," and "next to nothing;" and things which are considered "trivial," and, consequently, too little noticed, are often of vital importance, for instance, the electrical shaft signal invented and patented by Mr. W. Armstrong (Junior), which is available without the occupant leaving the cage to risk his safety in attending to "back shaft" work or otherwise cannot but prevent minor accidents as well as save life. It consists of an electrical appliance by which signals can be interchanged between the occupants of a cage and the engineman whether the cage is in motion or at rest. This is effected by inserting an insulated core in one of the strands of the winding rope, one end of which is attached to a ringing key in the cage, the other to a commutator on the engine shaft through which the current is taken to an ordinary single stroke bell; and

telephones can and have been used, and clear and distinct conversation carried on between the engineman and those in the cage at any position in the shaft. Another is the mechanical firing of boilers at Wingate Grange Colliery; for instance, by Henderson's patent, three boilers are doing the work of four with hand-firing. Another is Mr. R. Robinson's coal washer for coke ovens which saves 5 per cent. of the coal formerly lost by hand-washing.

Lastly, the original objects of the Institute, although now well known, cannot suffer by repetition. These have been described in the following terms:—

Prevention of Explosions.
,, ,, Accidents.
Raising the Standard of Profession of Mining Engineers.
Increasing Security of Life.
Security and Preservation of Health and Lives of Men.
As an Association of Practical Miners.
Improvement in Art of Mining Scientifically, and as a Literary Institute.

The Royal Charter confirmed these by stating as a condition of Grant that the Institution was for the prevention of accidents, and for the advancement of the science of mining and engineering generally. Sir F. Bramwell, as President of the British Association, at Bath, last September passed a very high eulogy on the Civil Engineers' profession, defining it to include all engineers except the "military," and thus embracing mining and mechanical engineers. May we, in our corporate as well as in our individual capacity, endeavour to uphold the high professional character and standard of usefulness indicated by him, and may I, during my term of office, be enabled to help forward the good work, and may my successor find accomplished some of the things I have referred to as now "left undone!"

Mr. Lindsay Wood said he had much pleasure in proposing a vote of thanks from the members of the Institute to the President for his address, which he was sure they had all heard read with pleasure. There was not a single scientific subject or practical subject connected with mining that the President had not dealt with in his address; and he was sure they were all greatly obliged to the President for his observations. The address would be of great benefit, and when they received it in print it would receive that consideration which he was sure it deserved from every one of the members.

Mr. John Daglish said he had much pleasure in seconding the vote of thanks proposed by Mr. Wood. Mr. Marley was a friend

of all, and to many of those who were fast reaching the end of their professional career he was an old and valued friend; and they were all glad and proud to see him occupying the position which he now so ably filled. He was sure that during his term of office, Mr. Marley's constant exertions would be given to forward the best interest of the Institute.

The PRESIDENT said he was much obliged and glad to receive their thanks, shewing that they approved of the aim he had in view, namely, the carrying out of the objects of the Institute—the advancement of their profession and standing, and the prevention of accidents.

# PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 9TH, 1889.

Mr. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting, and they were confirmed.

The SECRETARY reported the proceedings of the Council, and said that the Sheffield meeting on Federation had taken place, and would be followed by another in London. Probably, at the next General Meeting, the question would be brought under the consideration of the members. The minutes of the Council contained the following resolution :—

"It was agreed that leave should be given to writers of papers intended for the Institute Transactions to read such papers previously at the Sectional Meetings of the British Association in September next, it being understood that the Association claimed no copyright in papers, other than Reports of Committees nominated by itself, read before its Sections."

The PRESIDENT said this resolution of the Council was a matter of some importance. The British Association would meet in Newcastle in September next. Six-and-twenty years ago, when the Association met in Newcastle, an arrangement similar to what was now proposed was made, by which the members of the Institute were enabled to read papers at the British Association.

The SECRETARY having read the names of eleven gentlemen nominated for election at the next meeting,

The PRESIDENT said: I am very glad to congratulate you on the large number of nominations.

The following gentlemen were elected, having been previously nominated :—

ASSOCIATE MEMBER—

Mr. HERBERT THOMAS BURLS, Assoc. R.S.M., F.G.S., Mining Engineer, Barberton, Transvaal, South Africa.

STUDENT—

Mr. FRANK HAWTHORN BURN, Harton Colliery, South Shields.

Mr. T. O. ROBSON read the following paper :—

# NOTES ON THE VARIATIONS IN THE FAULTING OF COAL, OBSERVED IN THE ACTION OF THE SAME SERIES OF FAULTS IN THREE SEAMS AT REDHEUGH COLLIERY.

By T. O. ROBSON.

In the year 1886 the writer observed that a series of Faultings occurring at a distance of about 450 yards to the South of Redheugh Shafts and running in a South Westerly direction had—in the two Seams then proved, the Harvey and Brockwell—no apparent similarity of dislocation, although the headings prove them at almost exactly the same point.

Since that date these Faults have been proved in an intermediate Seam (the Top Busty), at a point somewhat to the West of the workings in the Upper and Lower Seams, but sufficiently near to enable a Section to be prepared showing approximately the Faultings as they appear in the three Seams, the one lying vertically under the other.

The Busty Seam is 12 fathoms below the Harvey, and the Brockwell 20 fathoms below the Busty Seam.

Although the connection of similarity is very slight, the following table is an attempt to co-relate the various dislocations.

The letters and figures used on the table to denote the Faults, refer to the Sections and Plans (plates II. and III.)

TABLE.

| HARVEY SEAM. | | | | BUSTY SEAM. 12 Fathoms below Harvey. | | | | BROCKWELL SEAM. 32 Fathoms below Harvey. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. on Section. | Description. | Hade. | Throw. | No. on Section. | Description. | Hade. | Throw. | No. on Section. | Description. | Hade. | Throw |
| A | D. S. Strong coal leader. | 13° | 5′ 0″ | | | | | X | Stone balk. | | |
| B | R. S. Strong coal leader and interposed fragment of bottom coal section of seam. | Vertical | 7′ 0″ | 1 | R. S. Coal of very poor quality, and thill of soft swelling clay. Top stone blue metal very soft and bad. | 45° in Seam | 1′ 4″ | Y | Overlap fault. D. S. Top coal appears between Y and Z. Not observed in same horizon for some distance North, and not met with South. | 45° | 3′ 0″ |
| C | R and D. S. With strong stone leader at Dip Fault. | 5° | 2′ 6″ up and down coal level through | | | | | | | | |
| D | Interposed post panel with strong coal leader on north face. This leader followed vertically down for 10′ 6″. Coal nearly level, and lying up against panel on south side | Vertical | Seam nearly level | 2 | Interposed post panel 5′ 0″ wide. Coal level on each side. | 17° | Seam level | Z | R. S. With strong stone leader (query equivalent of post panel in two upper seams). | 45° | 2′ 0″ |
| | | | | 3 | R. S. | 45° | 3′ 6″ | | | | |

The writer has frequently observed the altered action of a Fault in the same horizon over a considerable distance—but he does not know of a case where in the short vertical distance of 32 fathoms the character of the dislocation has altered so materially as in the case now noted.

There are four things apart from the peculiarity of the formation to which attention is drawn.

1. The dislocations are more frequent and decisive in the upper than in the lower seams.
2. The area affected in the upper seam is larger than in the seam below (the Busty, 12 fathoms), and the area affected in the Busty is also proportionately larger than that affected in the Brockwell 20 fathoms below.
3. The quality of the coal in the two upper seams is very much deteriorated between the points A and D and 1 and 3 respectively, whereas, in the Brockwell Seam, except at the point Y, the coal maintains the same quality throughout.
4. The top and bottom stone in the vicinity of the Faults in the two upper seams is much shattered and broken up—but the roof and floors of the Brockwell Seam is good throughout, except where the faultings actually occur.

It would appear, therefore, that the dislocation decreases as the depth increases, and that there is a point in depth at which the effect of the dislocation would be small and confined to one point—ultimately it may be disappearing.

The second case the writer has to describe is the alteration in the character of the same Fault (in the same three seams) as observed over a length of about 1,200 yards. The Fault runs in a south-westerly direction, and is met with about 150 yards north of the shafts.

At this point the Fault is undoubtedly a "trough." This is proved by the appearance above the Brockwell Seam (see Section A to B) of the Three-Quarter Seam, which was drifted into about 16 feet up. The throw of the strata, therefore, as calculated from the shaft section, is about 26 feet, and the Riser 28 yards further north throws the seam up about the same distance.

The same section of Faulting is seen at this point in the Harvey Seam, but there are no immediate data as in the Brockwell from which to calculate the throw (see Section A to B, Harvey, plate III.)

The nearest place to this where any seam has proved the Fault is in the Busty, at a point 165 yards south and west.

Here the coal leader remains strong, dips heavily 20 feet, then turns upwards, and the Fault appears so far as proved to be a "loop" Fault. (Section H to I plate II.)

At 360 yards further to the south and west the same Fault is proved in the Harvey, and is a riser north with very strong coal leader of 27 feet, followed by a dipper to the north of 4 feet 6 inches. (Section K to G plate II.)

88 yards further in the same direction the Brockwell Seam proves the Fault, and it appears as an ordinary Riser of 30 feet, with thin coal leader hardly discernable. (Section E to F plate II.)

The only seam which has been put through to the east is the Brockwell—and here as at the most westerly point the Fault is a Riser, but with strong coal leader about 30 feet (Section C to D plates II. and III.)

In this instance the alteration from a "trough" to the "loop" Fault, and subsequently to a Riser north is not easy to explain. I venture to think that from the point where the "trough" fault is most distinct both to the east and west, the dipper is gradually disappearing, and the riser becoming more distinct.

The Busty section goes to prove this theory as the dipper at this point, consists only of a bending of the seam, there being no proof of a distinct break.

And at the nearest point again to this in the Harvey, the seam lies level up to the Riser, the bending of the Seam observable in the Busty section having disappeared.

Mr. J. B. SIMPSON said he thought the paper an extremely interesting one, and if the members had more papers of this character they would be of great importance and help in the study of this particular subject. The Institute had had very few papers on Faults in this district, and he felt sure if some of the younger members would give a little more attention to local Faults, and describe them, we might be enabled to understand the way in which the various irregularities or Faults met with had been caused. Mr. Robson stated in his paper that the dislocations were more frequent and decisive in the upper than in the lower seams, and, so far as his experience went, he (Mr. Simpson) thought that this was pretty correct. He could give one instance of this which was in his mind at the moment. At the Towneley Colliery, in this neighbourhood, they had a Fault of 12 feet in the Towneley Seam, but this Fault did not extend to the seam called the Five-Quarter or Upper Busty, 15 fathoms below—

instead of it there was found a swelley or bending of this seam nearly equal to the amount of the Fault in the upper one. In this particular case the rocks in the lower part had only bent, but in the upper case they had cracked. There was another case at the same colliery—though somewhat different from the former one—at one particular place, the Towneley and Brockwell Seams, 30 fathoms apart, were free from Faults, but in the intermediate Five-Quarter Seam was a nip out of the seam for 45 yards, and extending over a distance of 200 yards. This showed how very peculiar Faults were—they might be found in one seam but not in another. The large Faults generally went right through; but Faults of less than 25 feet did not seem to go to the seams above or below. He only mentioned these cases to show the importance of this subject, and he was sure that a discussion would prove most interesting.

Mr. T. W. Benson said that Mr. Simpson had mentioned a nip out in the Five-Quarter Seam. There was a similar case south of the 90 Fathom Dyke, at a colliery he was connected with. In the Beaumont Seam there was a nip out of 70 yards, taking the seam out of it entirely; and in the Five-Quarter and the Brockwell Seams there was not the slightest trace of it. On the other hand, in another part of the same royalty, where the Whin Dyke is on the south side of the Main 90 Fathom Dyke, Mr. Buddle recorded, in the Transactions that were published by the Natural History Society some fifty years ago——

The President: In 1838.

Mr. Benson: The "putting through" the Whin Dyke in the Beaumont Seam, in the Fenham division of Benwell Colliery; and Mr. Buddle gave it as his opinion that, in all probability, this Whin Dyke would not go below this particular seam, *i.e.*, the Beaumont Seam, and that in all probability it would not affect the lower seams. Three or four years ago, however, he had reason "to put through" in this same Dyke in the adjoining West Kenton royalty, and, to his cost, he found that Mr. Buddle's idea was not correct, for there he had twice the quantity of whin that was shown in Mr. Buddle's section in the upper seam, and the coal on each side of this Dyke was deteriorated in value so much as to be unworkable for a great distance on each side.

Professor Merivale said it seemed to him that the consideration of this question divided itself naturally into two parts, as had been shown by Mr. Simpson. He thought the depressions were to be

accounted for by the fact of a certain seam having been nipped out and, having disappeared, whereas the seams below and above were still in existence. This was not difficult of explanation. The fact that dislocations did not always pass through all the seams was not understood, so far as he knew; and he should like to have more information upon this subject—more especially of the fact of the dislocation appearing in the upper seams, and not the lower. The general opinion was that dislocations increased as they descended, showing, apparently, that the force had been strongest at the bottom, and had died out gradually towards the top. This seemed to him to be a special problem for them to consider, and if they could collect more examples, they would be of interest, and would assist towards the solution of the matter.

Mr. G. B. FORSTER said Professor Merivale anticipated what he had intended saying. They should have more of these investigations into local dislocations. He thought they were in many cases —though not in all—due to the seam having been washed out, and the roof deposited in its place. Professor Merivale would remember the Broomhill case.

Professor MERIVALE: I am sorry to say I do.

Mr. FORSTER: There was an enormous nip out where the main seam had been replaced by sandstone. That it was washed out was shown by the various little islands of coal of a quarter of an acre and half an acre in extent, and the seam nipped out round about. He was not prepared to give an opinion as to the case of bending down shown by Mr. Simpson; but if they went to a pond where ice was breaking up, and especially where water had been drawn off, they would get a good idea of the great irregularity of fractures, and one which might account, to some extent, for these phenomena.

The SECRETARY said that, besides thanking Mr. Robson for the paper, he only wished to draw attention to the fact that in the case of these Faults, they really had part of a large subject, namely, the dying out of Faults. As a rule, they observed Faults when they were of considerable size, but took little trouble to find out what happened to them, or to see how far they were produced in different directions, east and west, north and south, or up and down. Every Fault must come to an end somewhere; and where they came to an end was often little known, especially in a district like this, where there was little metalliferous mining. If observations were made in local mines, and sections drawn to a true scale—not with an exaggerated vertical scale

—a great deal of light would be thrown upon this, which was one of the least understood problems in geology. He had himself given some attention to the subject, but he had always been stopped by the want of data. Mr. Robson, in this instance, had provided the kind of data which were wanted; and these were the kind of observations which could be made without travelling about. If gentlemen would make observations at their own collieries, and prepare correct maps and sections drawn true to scale, it would result in the speedy solution of this problem.

Professor MERIVALE suggested that Mr. Robson should prepare a paper on this subject, to be read at the British Association Meeting.

Mr. BELL said that similar dislocations or "balks" were found in the Main Coal and Low Main Seam districts of Cassop, Thornley, and Castle Eden. They were frequently met with, and extended from 30 to 50 yards in width; the Main Coal Seam was generally of increased thickness on each side of these "balks" as if pressed out by the weight of the superincumbent strata, so that practically none of the seam was lost; this thickening does not extend to the Low Main Seam, where frequent belts of thin coal are met with. There is a wide thinning or "nip out" of the coal in the Low Main Seam, commencing north-west of Belmont Grange, and extending through the Belmont, Broomside, Pittington, Littletown, and in the direction of Haswell royalties, where the coal is only from 9 to 13 inches in thickness, with no compensating thick coal on either side; this applies to the other districts named. The outer edges of the "balk" or "nip" show no signs of breaking, but merely a bending of the roof; there was no appearance of any washing out in either seam, and he could not trace water as being the cause of this, neither were there any Faults in the vicinity of these "balks" in the lower seams.

Mr. J. B. SIMPSON said that, with reference to Mr. Bell's remarks, in the Five-Quarter Seam at Towneley they found the seam double in thickness for a breadth about equal to the breadth of the nip out, on one side of the nip out only; and this occurred over a distance of about 200 yards in length. In some places the nip out was as long as 45 yards across, and in every instance the coal was found double or more in thickness at the side of the nip out.

Mr. BELL: Yes, that is the case.

Mr. W. H. HEDLEY said the cause of a nip out in such a case as Mr. Simpson had referred to, might have been pressure rather than the action of water, as in the case referred to by Mr. Forster.

The PRESIDENT: Denudation.

Mr. HEDLEY: As to the section where the Towneley Seam was shown to be dislocated by a Fault of some 12 feet, and with only a bending upwards of the seam below, it struck one that this might be accounted for, by an action of upheaval taking place from below, which only sufficed to bend the lower beds, the resistance on them being greater, while in the upper beds, where the weight above and resistance were less, there would be force enough to break.

The PRESIDENT said he wished to know whether Mr. Robson had been able to draw any result or line as to where the action of the force had begun, or whether it had really taken the power from the lower seam and affected the upper; or whether it was in the upper seam and not in the lower one that the action had begun?

Mr. ROBSON said that, in the case of the first set of Faultings described in the paper, he had not come to any conclusion at all. In the three Faultings the Harvey was much dislocated, the Busty less, and the Brockwell less again. The dislocation in each case was so different and thoroughly distinct that it seemed almost impossible to correlate them. He had put them in the form of a table, but it was not a correlation, but only putting them together in a convenient way for comparison. He could give no theory which would account for the peculiarity of the dislocations. It seemed to him a puzzle, and, as a puzzle, he brought it before the members of the Institute, in the hope that someone would unravel it.

The PRESIDENT: The reason I asked the question was, because in the paper Mr. Robson has not attempted to deduce any theory.

Mr. ROBSON: I have not at all.

Mr. J. B. SIMPSON asked Mr. Robson to add to his paper the thickness of strata between the seams.

Mr. ROBSON: The distance in the shaft between the Harvey and the Busty is twelve fathoms; and between the Busty and the Brockwell twenty fathoms; making thirty-two fathoms between the top seam and the bottom in the shaft.

Mr. BELL: Have you any upper seams?

Mr. ROBSON: Four upper seams are there, but, unfortunately, we cannot travel into them.

Mr. J. B. SIMPSON: Are there any large Faults in the immediate neighbourhood of the two Faults described?

Mr. ROBSON: No; the Heworth Fault is 70 chains to the south. The Heworth Fault is the main Fault of the district.

The PRESIDENT: Do your Faults run, as a rule, in one given direction?

Mr. ROBSON: Yes; the main Faults have a general south-westerly direction.

The PRESIDENT: Have you any doubts as to your correlating the seams, whether the Harvey, or Brockwell, or what?

Mr. ROBSON: No.

Mr. G. B. FORSTER: It is a well-known tract of coal.

Mr. ROBSON: I have not the slightest doubt about these being the same seams on each side of the dislocation.

Mr. BELL: Have the upper seams been worked?

Mr. ROBSON: Yes, many years ago.

Mr. BELL: Can the Faults be traced on the old plans of the upper seams?

Mr. ROBSON: I have not seen the old plans of the upper seams, but I think Mr. James Easton had most of these old plans in his possession. I do not know where they are now.

Mr. BELL: It would be interesting to know whether the Faults extend from the Harvey to the upper seams.

Mr. ROBSON: Unfortunately I have no plan of the upper seams.

In reply to Mr. White,

Mr. ROBSON said: The section of the Busty Seam Faulting is 66 yards to the west of the point where it is taken in the other two seams; but I have for the purpose of comparison placed them one under the other. This is not a strictly correct way of doing it, but I think it is correct enough for this purpose.

The PRESIDENT: You mention this in your paper.

Mr. ROBSON: Yes.

Mr. J. B. SIMPSON: Does the Brockwell Seam extend a long distance beyond without further Faults?

Mr. ROBSON: Yes, and it is perfectly level, and so also is the Harvey Seam. I cannot say the same for the Busty Seam, as it is improved.

The PRESIDENT: At one place you say that the Faults are large in the upper seam, and less in the next lower; and so you reverse the rule.

Mr. ROBSON: The ordinary rule is I think that a Fault is stronger in the bottom seam, and dies out towards the top. That has been my general impression; in this case the rule is reversed.

The PRESIDENT: I think Mr. Robson has brought forward a subject of importance, especially when he attempts to correlate the

seams; and I hope we will have a paper on the subject from Mr. Simpson at the next meeting. The discussion of Mr. Robson's paper will be adjourned.

On the motion of the PRESIDENT, seconded by Mr. J. B. SIMPSON, a vote of thanks was passed to Mr. Robson for his paper.

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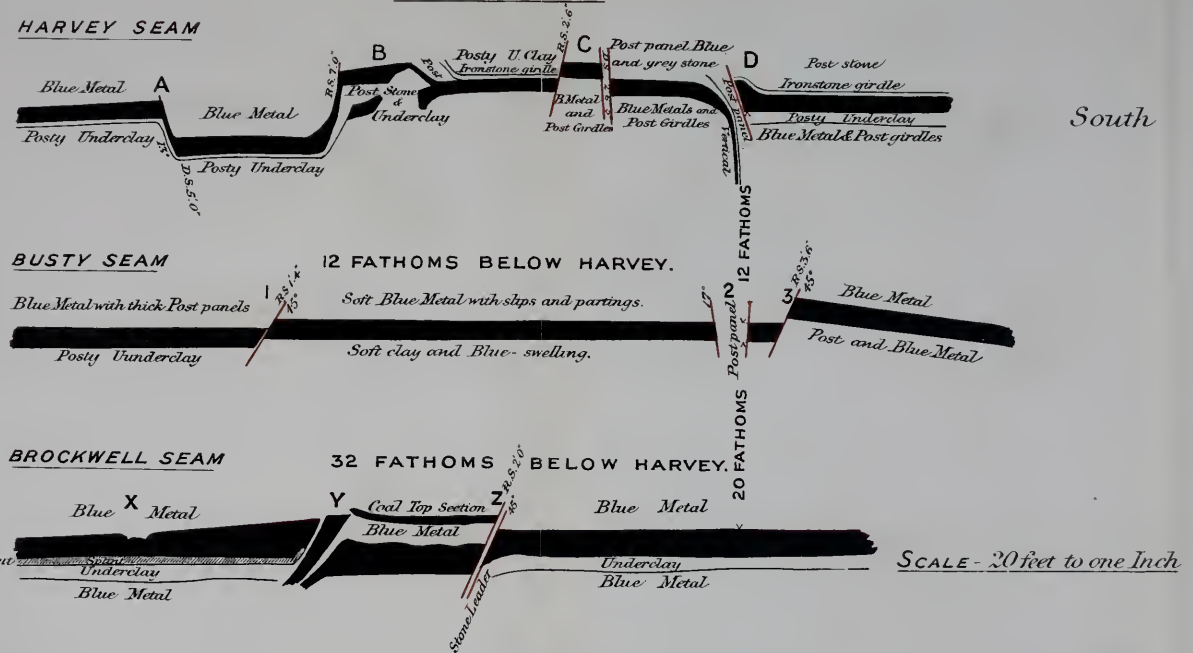
The following paper on "Outbursts of Gas in Metalliferous Mines," by Mr. Bennett H. Brough, was read:—

$S_2$

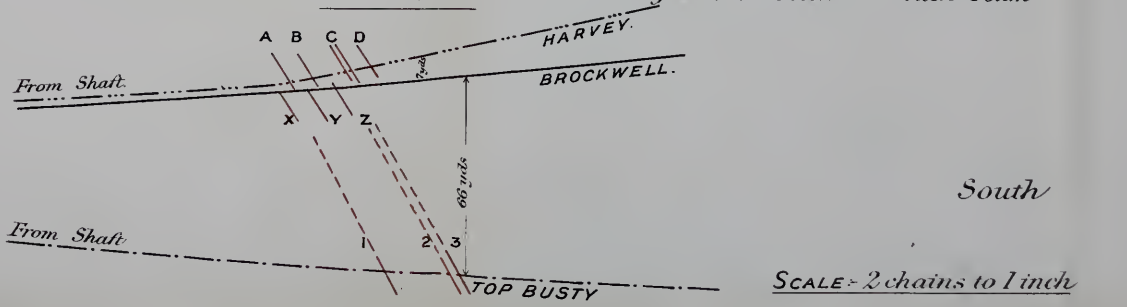
W.

*To illustrate Mr. T. O. Robson's paper "On variation in the Faulting of Coal at Redheugh Colliery."*

## — SECTIONS. —




## — PLAN — *Shewing line of Section in each Seam*

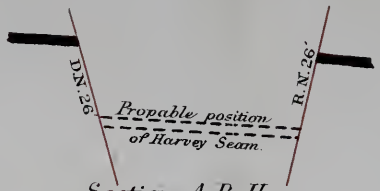




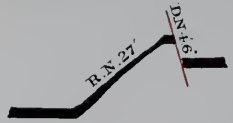

Lambert & Co. Lt. Newcastle

*To illustrate Mr. T. O. Robson's paper "On variation in the Faulting of Coal at Redheugh Colliery."*

## SECTIONS.




Section A.B. Harvey.




Section K.G. Harvey.

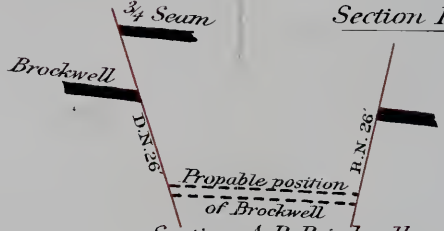
SCALE:- 40 feet to One Inch.

Section H.I. Busty.

South.

North

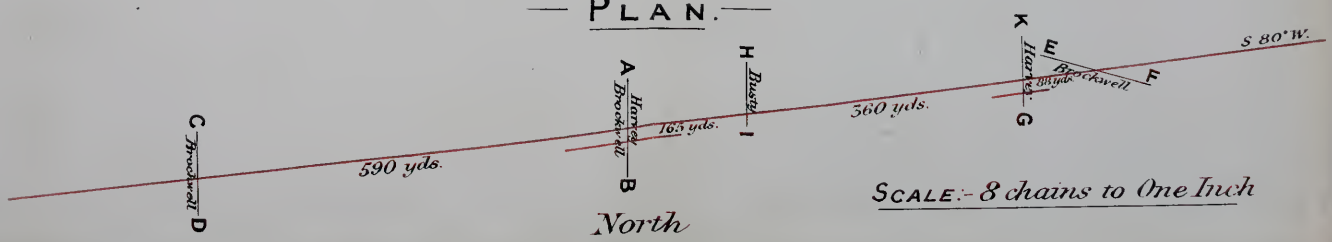
Section C.D. Brockwell.




Section A.B. Brockwell.

Section E.F. Brockwell.

## PLAN.




SCALE:- 8 chains to One Inch

North



Lambert & Co. Lt. Newcastle

# OUTBURSTS OF GAS IN METALLIFEROUS MINES.

By BENNETT H. BROUGH, Assoc. R.S.M., F.G.S., F.I.C.

THE recently published volume of the Reports of the Inspectors of Mines to Her Majesty's Secretary of State contains an account of a lamentable accident, caused by a fire-damp explosion, at the Mill Close lead mine, at Darley in Derbyshire, on November 3, 1887. This mine, which is the largest and most productive in Derbyshire, is one of the oldest in the district, the records of the quantity of ore raised going back as far as the year 1684. The vein is frequently many yards in width, and traverses hard limestone overlain by shale. Ore is also found extending into many of the beds of shale. Fire-damp has occasionally been found in this mine, but only in small quantities. In 1886, however, two explosions occurred, by which two men were burnt. Since that date the quantity of gas emitted from the shale largely increased, and led to the use of locked safety-lamps. The account of the recent explosion given by Mr. Stokes (*), H.M. Inspector of Mines, is substantially as follows:—On the morning of the accident, six miners went to work at a part of the mine called the forefield. They descended at midnight on November 2. Upon their arrival at their working place, the men tested for and found gas in and about the ends of the forefield. They thought, however, that the use of safety-lamps protected them from all danger. A shot was fired during the early part of the shift, and at 3 a.m. three shot-holes were bored, within 3 or 4 feet of where the gas was known to have accumulated. These holes were charged with dynamite, and ignited by touch-paper, and a fuse carried down from the upper to the lower workings. After lighting the fuse, the men retired to what they thought was a place of safety about 50 yards away in the lower level or waggon way. At this point they were

(*) Reports of the Inspectors of Mines for the year 1887, London 1888, p. 377.

joined by the two waggoners, and all awaited the firing of the shots. Suddenly an explosion occurred, and immediately 5 of the 6 men were buried and killed by a large fall of timber and stone. The sixth man escaped with burns and serious bruises. This man stated at the inquest that the explosion took place immediately after he heard the first shot go off, and from his evidence there can be little doubt that the first dynamite shot fired the gas.

The Yoredale shale, whenever it occurs in beds of 25 to 35 fathoms in thickness, always gives off a little gas. Probably this gas had collected in the fissured limestone, and, becoming ignited by the shot, forced down the rock masses upon the unfortunate miners.

This illustration of the disastrous effects of a fire-damp explosion in a metalliferous mine clearly proves that fire-damp, unfortunately, is not confined to collieries. In a number of cases it has been met with in mines of lignite, salt, diamonds, and metalliferous minerals. It has, therefore, been thought that it would be of interest to collect the records of cases in which outbursts of gas have been observed in metalliferous mines, with a view to arriving at an explanation of the phenomena.

Numerous cases are recorded in which, as at the Mill Close Mine, fire-damp has been emitted from the Yoredale shales of Derbyshire. According to J. Farey (*), in Eyam registry, there are records of men having been killed in Stoke sough (adit-level) in 1732, 1734, and 1778, by explosions of fire-damp. Pilkington (†) records several men having been killed by an explosion of "inflammable air," in driving the famous Hillcar sough, near Youlgreave. This adit-level passes through the Yoredale shale for two or three miles, and, with a candle at the end of a stick, up to a very recent date, visitors used to light the thin stream of gas along the roof. This would flash along almost the whole length of the level. The gas is now exhausted, or is present in very small quantities, but, when new ground is cut, there is a decided emission of gas.

The emission of fire-damp from the Yoredale shales can be easily accounted for when the bituminous nature of these shales is considered. The occurrence of solid and liquid hydrocarbons in the Yoredale shales, and in the veins near or under them, has been noticed for many years. Dr. T. Short, (‡) writing in 1734, gives the following account of the Hucklow Edge vein near Eyam :—

(*) General View of the Agriculture and Minerals of Derbyshire, London, 1811, p. 333.
(†) A View of the present state of Derbyshire, 1789, p, 171.
(‡) The History of the Mineral Waters of Derbyshire, 1734, p. 96,

"It is remarkable that in the Lead Mines . . . was a bed of *Boulder* Stones, any one of which being broken into contains from half a Pint to a Gallon of soft *Bitumen* like *Barbadoes* Tarr, it melts before the Sun or Fire to Oil; there were also several Springs in the Mines, that took Fire with a candle and would burn a Week or Fortnight, and all the Water drilling through this *Stratum* of *Boulder* Stones will take Fire and burn many Days. This Bed was continued between two or three Miles, all along Hucklewedge with its burning waters. Several Damps have happened at these Mines without any preceding visible Cause or Sign, but all being serene and clear in the Works without Fog or Mist; the Sulphur in the Air would fire at the Miners' Candles, the Flame run from one End to the other, with a thundering Noise, making the Earth shake, and in two moments the Sulphur was spent, the Fire extinguished of itself, and all clear again. The only Shift the Workmen have is to clap down on the Earth instantly on their Faces till it is over."

The explosions here recorded are undoubtedly similar to that at the Mill Close mine. At the latter mine, a hard, black, brittle variety of bitumen is of frequent occurrence.

Similarly, the fire-damp explosions that have occurred in salt mines are due to the presence of hydrocarbons produced by the decomposition of vegetable substances. The grey or blue colour so frequently met with in rock salt is due to the presence of bitumen. In several localities, notably at Stassfurt, in Prussian Saxony, and at Wieliczka, in Poland, the salt contains bubbles filled with various compressed gases (hydrogen, carbonic acid, and carbonic oxide), which, when the salt is dissolved, give rise to a crackling noise. Liquid inclusions in rock salt are extremely frequent. Some are visible to the naked eye, others are microscopic. The enclosed material is usually a hydrocarbon. According to J. N. Bremer (*), combustible gas was evolved in large quantities from a fissure in the marl in the rock salt at the Szlatina mine, Marmaros county, Hungary, and was used for lighting the workings. At Gottesgabe, near Rheine, in Westphalia, the gas evolved was used in 1826 for lighting the workings, and even conducted through wooden pipes to the manager's house, and there used for lighting and for cooking purposes. Similar outbursts of gas were utilised at Zugo, near Klein Saros, in Transylvania (†); and at the Bex salt mines in the canton of Vaud, Switzerland, fire-damp has, according

(*) Poggendorff's Annalen der Physik und Chemie, vol. vii., 1826, p. 131.
(†) Gilbert's Annalen der Physik, vol. xxxvii., 1811 p. 1.

to Brunet (*), been used for lighting the workings, being received from the fissures in sheet iron pipes. The gas probably comes from the enclosing limestones, which are possibly bituminous. It is a curious fact that the first fire-damp explosion recorded is shown by Professor F. Posepny (†), to have occurred at a salt mine at Hallstadt, in Austria, on September 9, 1664, twenty years before what is generally supposed to be the first historical evidence of the presence of fire-damp, given by Robert Plot (‡), in 1684.

In iron mines, several explosions of fire-damp have been recorded. A. Daubrée (‖) met with fire-damp in the mines of pisolitic iron ore at Gundershoffen and Winckel in Alsace. At Gundershoffen, the pisolitic iron ore, which was worked up to 1825, occurs disseminated through a yellow clay overlying marls of Upper Liassic age. The ore-bed is covered by a greyish blue clay, some 20 yards in thickness. In the bed, numerous nodules of gypsum are met with, and the clay immediately above the deposit is impregnated with grains of iron pyrites. In the bed, which was worked in 1818 at a depth of 33 yards, insignificant gas explosions were of frequent occurrence. In 1824, however, a serious explosion occurred, by which a number of miners were seriously injured. The Winckel bed is deposited in a hollow in white limestone of Upper Jurassic age. The pisolitic iron ore is disseminated through a grey clay, and the whole is overlain by a limestone conglomerate. In 1832, an explosion occurred when some workings, that had been suspended for a time, were entered. Wooden planks were ejected from the shaft and thrown to a distance of 10 yards from the mouth, and the only workman in the mine at the time was badly burnt. An explosion of a less serious character occurred on June 27, 1846. At the end of a level, a great influx of water was observed, and in raising his light to see whence it proceeded, the captain ignited the gas, and was thrown violently to the ground and slightly burnt.

Castel (§) mentions an explosion of fire-damp which occurred on November 15, 1853, at the Voulte iron mine, by which many miners were seriously burnt. The ore-bed at Voulte is enclosed in black marls of Middle Jurassic age, underlain by mica-schists in uncomformable stratification. The gas was ignited by a spark from a miner's pick. In this case the presence of gas appears to be due to the existence of a gasey lignite in the marl at a slight distance

(*) Comptes rendus mensuels de la société de l' industrie minérale, 1882, p. 129.
(†) Oesterreichische Zeitschrift für Berg- und Hüttenwesen vol. xxxiii. 1885, p. 606.
(‡) Natural History of Staffordshire.
(‖) Annales des mines, 4th series, vol. xiv. 1848, p. 33.
(§) *Ibid.*, 5th Series, Vol. VI., 1854, p. 94.

from the ore-bed. In mines working true fissure veins, numerous explosions have been recorded. In March, 1845, an explosion occurred in old workings that had not been entered for some years, at the now abandoned copper mine of Grand-Saint-Jean, near Giromagny, in Alsace. Gas has been noticed on several occasions at Pontpéan, in Brittany, where it is still occasionally met with. (*) The vein consists of argentiferous galena and blende, and traverses, in a north and south direction, the ancient clay-slate. As there is a dislocation that has brought a portion of the deposit to the level of the Tertiary strata, it is possible that the gas outbursts are due to the influence of lignite deposits, which may exist in these beds.

Charlon (†) reports the occurrence of inflammable gas in the copper pyrites deposit of Rocca Federighi, in Tuscany. In 1875, a timbered level that had been abandoned for two or three years was encountered by a cross-cut. On holing, large quantities of water were ejected, and, immediately afterwards, an explosion occurred by which three workmen were seriously burnt. Again, in 1877, at the same mine, an explosion occurred on opening an old adit level that had been abandoned for 15 years. In this case a thin parting of rock separated the old level from that in which the men were working, and water having an unpleasant odour percolated through. A piece of the roof fell, and the captain, raising his lamp to see what was the extent of the disaster, exploded the gas, the three men in the level being seriously burnt. From this description it appears that, under certain conditions, the decomposition of wood in water or in moist air may give rise to the formation of inflammable gas in exactly the same way as marsh gas is produced in stagnant pools. The explosions that have occurred in some of the Saxon mines when old workings were entered, may be explained in this way. The archives of the Royal Saxon Mining Bureau, quoted by Tittel, (‡) record several explosions of this kind. At the St. Johannes Mine, at Rehhübel, in the Schwarzenberg district, a cross-cut was driven from the Urbanus adit level, at a distance of 760 feet from the mouth of the adit. On March 11, 1872, two miners were working at the end of this cross-cut, and at noon a quantity of water burst through. At 3·45 p.m. an explosion of gas occurred. One of the miners, though badly burnt about the head, face, and hands, found

(*) Rapport de M. Haton de la Goupillière au nom de la commission d'étude des moyens propres a prévenir les explosions du grisou, Paris, 1880, p. 39.

(†) Comptes rendus mensuels de la société de l'industrie minérale, 1879, p. 6.

(‡) Berg. und Hüttenmännische Zeitung, 1882, p. 226.

his way in the dark out of the adit and escaped. The dead body of the other miner was found at a distance of 643 feet from the mouth of the adit. It was subsequently found that the water from an old shaft accompanied by marsh gas, which had in all probability been formed from the decaying timbers, had burst through an aperture, and become ignited by the miners' lamps.

At the Churprinz Friedrich August mine, at Gross-schirma, in 1859, a brick dam was put in to keep out the surface water. In 1882 the system of drainage was changed, and the dam was bored through in order to insert an iron pipe provided with a cock for letting off the water as required. While the boring was in progress, water and gas burst through, and an explosion followed by which the miners engaged were seriously injured. Similarly, at the Alte Hoffnung mine at Schönborn, a dam built in 1867 was opened in 1870, in order to ascertain whether there was as much water as formerly. The gas, issuing with the water, ignited, and the flame extended for 20 feet and burned for several seconds. Behind the dam, the level had been timbered for some 30 yards.

The presence of fire-damp in metalliferous mines cannot always be traced to the decomposition of timber under water. There was very little timber in the Winckel levels, and none at all in the Giromagny mine. In many mines, too, containing an enormous quantity of timber partially submerged, no trace of gas has been observed. This was the case at the Alter deutscher wilder Mann mine, near Grund, in the Upper Harz. This mine was under water for 200 years, and was visited by the writer in 1882, immediately after the water had been pumped out.

Another explanation must be sought for the presence of fire-damp in the Monte Catini mine in Tuscany, where in 1845 many miners lost their lives by an explosion, and in the celebrated Van mine near Llanidloes. The latter mine is the most productive lead mine in the United Kingdom. The vein occurs in rocks of Lower Silurian age. The occurrence of gas at this mine has been noted by Dr. C. Le Neve Foster. (*) Fire-damp was found at the adit, and in nearly every level below while tapping or making the first drivages on the lode. The gas rushes out with the water, making a great noise, and always appearing to come from below. The miners regard it as a sure harbinger of lead ore. The quantity has sometimes been sufficient to cause slight explosions, by which miners have had their hair and beards singed. It is not improbable that sulphuretted hydrogen has also been emitted.

(*) Transactions of the Royal Geological Society of Cornwall, Vol. x., 1879, p. 33.

T. Macfarlane (*) describes the occurrence of fire-damp in the Silver Islet mine, situated on a small rocky island in Lake Superior. On December 28, 1875, while a party of miners were engaged in drilling a hole in the end of the drift at the 8th level, the drill suddenly broke into a crevice, from which water at once commenced to flow, but not in great quantity, and not being aware that it was accompanied by an emission of gas, one of the miners took a candle to look at the hole. The gas instantly took fire, sending out a flame of more than 40 feet in length. The hole was subsequently stopped with a wooden plug, and when a lighted candle was applied to the imperfectly plugged hole, the gas again ignited, giving a jet of flame about a foot in length, which continued to burn for several weeks.

In these cases, it appears probable that the gas has been derived from beds beneath the ore-vein, from which it has ascended through fissures into the workings.

Sulphuretted hydrogen has, in many places, being disengaged in sufficient quantity to become ignited, This occurred during the sinking of a well at Gajarine, near Conegliano, in Lombardy, and is described by L. E. F. Héricart de Thury. (†) The explosions described above cannot, however, be attributed to this cause, for if sufficient sulphuretted hydrogen had been present it would at once have been detected by its characteristic odour, and by the odour of the sulphurous acid formed on its combustion.

The oldest description of the occurrence of sulphuretted hydrogen in mines is given by A. A. Barba, the director of the Mines at Potosi, in Peru, who in 1640 published a Spanish treatise on mining. (‡) The description, as given in the Earl of Sandwich's translation (‖) is as follows :—

"Some do think that there is some Matter in the Bowels of the Earth so stinking and abominable, that it doth correspond with the Ordure of Animals: The Truth is, that there be places in the Earth that instantly kill, with a pestilential Smell. And setting aside the Stories of this kind, both ancient and modern in remote Countries, I shall relate two Examples, where I myself was present, which was at the Discovery of the rich Country of *San Christoval de los Lipes*; at that Time in a beautiful high Hill, that together with others encompasses the Dwelling of the Miners,

(*) Transactions of the American Institute of Mining Engineers, Vol. viii., 1880, p. 226.

(†) Annales des mines 3rd series. vol. iv. 1833, p. 515.

(‡) Arte de los metales, Madrid, 1640.

(‖) The Art of Mettals, London, 1670.

two *Galleguares* found a Mine, which at first they called after their own Names, but ever since, to this present, it is called from it's Effects, *The stinking Mine.* At first they got out of it very rich Oar between white Chalk : And as they began to sink deeper they were forced to give over by reason of a most abominable ill Smell they met withal, which killed several of the Miners, *Indians*; and so it lay unwrought for four or five Years : After which Time another Miner (I being then in the Country) undertook to proceed in the working of it ; thinking that having lain so long after it's first Opening, the ill Quality would have been evaporated ; but that Experiment cost the Lives of two *Indians* more, whereupon they forebore the Work, and have done so unto this Day. The which I have not so much wondered at, as to see with my Eyes the Ground opened in several other parts of the Mountain, at a great Distance from the forementioned Mine, and in digging scarce a yard deep, such a Stink came out of the Ground as forced the Labourers to give over: And as I passed by those Pits a few Days after, I saw divers Birds and Serpents dead in them, having been intoxicated by that poisonous Smell."

"In the famous Country of Mines, *Verenguela de Pacages,* in which the *Indians* procured a Patent to dig, before that of *Potosi* was in Use, because it's veins were esteemed much richer than *Potosi,* and upon Trial were found to be so ; and the Oar gotten there inferior to none in the *Indies.* In the Hill of that Country called *Saneta Juanna,* a Miner followed a very rich and plentiful Vein of Silver, and intending to discover more of the like, he determined to break a hole into an old Vault, and set two *Indians* upon the Work, who after a few Blows discovered a Vacuity, out of which came so pestilential a Stink, that killed the two *Indians* presently, and almost stiffled others that were at a Distance from them in the Mine, who nevertheless ran out and told their Master what had happened. He made haste to the Mine, hoping to save the *Indians,* but at first Entrance into the Ground, upon the Stairs by which they went down into the Mine, he fell down dead, and his Body remained there, no Body daring to go down and take it away to bury it."

In these cases, the gas was probably produced from the decomposition of pyrites ores. This decomposition may be detected in many old mines. The writer has observed the presence of large quantities of sulphuretted hydrogen in abandoned workings at the Rammelsberg mine in the Harz, at the Falun mine in Sweden,

and at several of the Hungarian mines. In other cases, the acid waters produced by the oxidation of pyrites act on limestone and produce carbonic acid. Emanations of carbonic acid in the iron ore mines of the Upper Erzgebirge are described by H. Müller. (*) Similar outbursts have been observed at the mines of Massa Maritima, in Tuscany, where a thick vein of pyrites and quartz traverses clay slate enclosing limestone beds. The hanging wall of the vein is formed by a band of clay that conducts a quantity of water into the workings, and serves as a receptacle for gas, principally carbonic acid, probably produced in the manner indicated. A similar reaction may have produced the large quantities of carbonic acid given off from crevices in the south wall of the lode at the Foxdale lead mines in the Isle of Man. In 1883, when the writer visited these mines, the amount of gas given off at the eastern end of the 185 fathom level was so great that, notwithstanding the large volumes of compressed air continually forced in from two air pipes, candles would not burn and the work was carried on under great difficulties.

In the same way, carbonic acid was met with in 1875 in the Johannis Stehenden vein, in the Himmelsfürst Mine, at Freiberg, in Saxony. Here, too, lights would not burn before a freshly opened cavity.

Carbonic acid, produced by the action of acid waters on limestone, is of not unfrequent occurrence in the Derbyshire lead mines. At a mine near Youlgreave, the writer has seen this gas being raised in buckets attached to a windlass. An early account of the occurrence of carbonic acid is given by William Hooson, a Derbyshire miner, in a quaint work (†) published in 1747. The effect of the gas on the miners is described in the following terms:—

"All Miners both Antient and Modern give this Account, That they never feel any sensible Pain or Disorder, but after a most pleasant way, it takes the whole Use of all their Limbs, and they settle down, as a Man falling asleep, feeling nothing at all, but an extraordinary Sweet and Lushious Taste and Smell, that beguiles and ravishes the Senses in a Moment.

This is the whole Account that we Miners can give of it; and this so far as the Memory continues, after being seased or tapished with it, and being drawn up by the Heels for dead, yet have Recovered; but never could such Men Remember, or give any

(*) Gangstudien, vol. iii., 1860, p. 302.

(†) The Miner's Dictionary, explaining not only the terms used by miners, but also containing the theory and practice of that most useful art of mining, more especially of lead mines. Wrexham. 1747.

Account of the least Pain they ever felt in it. And now give me leave to tell you the best Preservative we Miners know of, and verily think is of great Force against it, we have it delivered to us by the old Miners, and many I have known to confirm the same; but here are two Examples, the first I was not present at, being more than two Miles from where I then was; the other in our Liberty, and my Brother one of them, the former was thus: Two Miners Sinking a Shaft in hard Shale near 20 Yards deep, it happened the Ground-Damp bred in it; one of them went down, his Partner of a considerable time after hearing nothing of him, and knowing it was Windless, began to suspect the Matter, and forthwith calls his next Neighbours, and tells them what he fear'd; having now some Company, down he goes to see what the Matter was, and soon was damped likewise; and now more Company coming in, one young bold Man ventures down and has the same Fate; and after him (the Depth of the Shaft being so small) two more, and those damped likewise: This put the whole Company to a stand, and as they were considering to carry Wind down in Trunks, by chance a Tinker seeing a crowd of People, turns out of his way to see what was a doing there; having heard the Matter, he said it was no difficulty to fetch them up; (the Man had been drinking all Night, he feared no Danger, nor could any persuasions stay him from his design) he throws by his Budget and puls off his Coat, and down he goes, ties the dead Men in the Rope one by one by the Heels, and after climbs up himself, without any Damage, only when he came up again into the fresh Air, he Vomited most violently, and was most deadly Sick; therefore it was concluded that the Fumes and Strength of the Ale preserved him, according to the old Miners' Opinions."

In the second case described, an old miner ties the bodies of three miners, suffocated by the gas, to the rope, and finally comes up himself. "This man," writes Hooson, "had been Drinking all the Day before, and most part of the Night, so that it should seem not to work so soon upon a man well steeped in Ale. Many Men's Lives have been saved after this Manner, which seems to be an Act of Providence rather than any foresight, or care that a Man has of himself, and indeed I never yet knew nor heard of any Man that was Sober, durst be so bold to take a sufficient Dose of Ale on purpose that he might the better encounter it."

## SUMMARY.

From the various records collected in this paper, it is believed that there is sufficient evidence to show that the gas outbursts, that have been observed in metalliferous mines, are not all due to the same cause, and may be explained by the following hypotheses :—

1. The decomposition of timber in a mine, in a similar manner to the decomposition of vegetable matter in marshes, may produce fire-damp which would accumulate in cavities that are ultimately broken into. This is evidently the explanation of the explosions in the Saxon mines, and in the Rocca Federighi mine.

2. In iron mines, where the iron is not entirely in the state of peroxide, water might be slowly decomposed, and hydrogen be produced. This, if the ventilation of the mine was defective, would accumulate in the upper portions of the underground excavations. This is a possible explanation of the explosions at Gundershoffen and Winckel.

3. In these cases, however, it is more probable that the gas was fire-damp, which emanated from beds beneath the ore deposit, and found its way, through fissures, into the workings. The gas would thus be produced in the same way as the natural gas of the United States, China, and other countries, where it is given off from rocks of varied age enclosing bitumen. The Upper Liassic marls on which the Gundershoffen deposit rests are often sufficiently bituminous to enable them to be burnt. At Winckel, however, no such beds are met with below the deposit, though they occur in the Jurassic rocks of the vicinity. The same explanation is therefore feasible. At the Mill Close, and other mines in Derbyshire, the gas is derived from the Yoredale Shales, which are undoubtedly of a bituminous character. Bituminous matter has occasionally been found in mineral veins, and would appear to have been derived from the adjacent rock at the time of the filling of the vein fissure. In the Snailbeach lead mine in Shropshire, small nests of bitumen abound in the vein, and the writer has found the same substance in geodes in some of the abandoned metalliferous mines of Alsace, near Mollau and St. Amarin, in the Vosges. The explosions at Monte Catini, Silver Islet, and the Van mines would appear to be due to natural gas derived from adjacent rocks.

4. Fire-damp may be produced from the decomposition of

organic matter, in the same way as the hydrocarbons met with in salt mines. At Pontpéan, and at the Voulte mine, the fire-damp was apparently derived from beds of lignite in the vicinity.

5. Explosions have in some cases been caused by outbursts of sulphuretted hydrogen, produced by the action of acid waters on pyrites ore.

6. The outbursts of carbonic acid met with at Foxdale, Freiberg, and Massa Maritima, may have been caused by the action of acid waters, produced by the oxidation of pyrites, on limestone or metalliferous carbonates.

Professor BEDSON said he thought this paper, which they had had the pleasure of listening to, was one of very great value, inasmuch as it presented to the members an account of the different kinds of gases which were met with in different mines, giving a history of the subject, and many valuable observations from the author's own experience. It was always of great service to have such a paper as this in their Transactions for reference. In his own experience he had frequently found it a matter of great inconvenience to find data relating to such matters as outbursts of gases in metalliferous and other mines. Some two years ago he had analysed samples of gas obtained from the salt deposits at Middlesbrough, and experienced great difficulty in not being able to examine the results of the analyses of gases from other salt deposits. The writer of the paper referred to the Wieliczka gases, and, so far as he (Professor Bedson) could remember, an account of the analysis of those gases by Professor Bunsen is to be found in Richardson and Watts' Dictionary of Applied Chemistry. A point in the paper worthy of careful consideration were the various hypotheses which the author put forward to account for the finding of the different gases in the different mines. The decomposition of timber as resulting in the production of fire-damp, was a very important observation.

Mr. JAMES WILLIS said it was a frequent occurrence to have slight explosions of gas in the hematite mines of Cleator, and other places in Cumberland. Last year one man was killed by such an explosion in the Furness district. If the writer of this paper would go to the places, he might have an opportunity of examining these gases. The supposition of the writer was that the gases referred to in the paper arose from the decomposition of wood.

The PRESIDENT: You are speaking of the explosions in hematite mines?

Mr. WILLIS: Yes.

Mr. T. BELL: Are there any shales in connection with the hematites there?

Mr. WILLIS: Not any.

Mr. WHITE said that when he had charge of the South Skelton iron mine in Cleveland, there were two men very badly burnt indeed. For some time they were so very much bothered with gas that Davy lamps had to be used in working some parts. In the Liverton Mine, near to South Skelton, they had always, he believed, had some trouble with gas. For a considerable period there was an oily fluid to be seen trickling down the sides of the bords from the roof in the ironstone mine. In his case the timber had nothing whatever to do with the matter.

The PRESIDENT: Did you form any conclusion as to where it came from?

Mr. WHITE: Undoubtedly it came from the roof, and we had trouble with it at South Skelton for some months.

Mr. BELL said he thought it was from the jet shale that the gas came into the Cleveland mines. In one of them he had seen more gas than in a coal mine. As to gases in metalliferous mines, he had seen some in two or three places traceable to some shales. In another instance, where a man was burnt, there was a small coal seam 6 or 7 inches thick, where the gas had evidently come from, and exploded at his light. It was a common thing in all lead mining districts to have gas here and there from the shale, or small coal seams, or from both of them. In the place Mr. White spoke of he (Mr. Bell) had traced it as coming from the jet shale.

Mr. STEAVENSON, referring to Cleveland, said there were three or four instances where the very first time a jud was drawn, when commencing to work a new Broken district, gas had come off causing slight explosions, but afterwards the carbonic acid from the goaves usually rendered the explosive gas harmless.

Mr. W. H. HEDLEY asked if it was necessary, as the writer of the paper and some of the speakers seemed to think, to seek to account for the presence of gas solely from causes existing in or very near to the bed where it occurred. There were sources for the formation of gases deep down within the bowels of the earth; and the gas which was found in the coal measures, as well as in iron

and other mines, might have also a source some considerable distance below where actually met with.

Mr. J. M. LIDDELL said that in the diamond mines of South Africa there was a great amount of carboniferous shale, and in working amongst it there had happened one or two explosions. In one case a shaft was sunk through a small amount of shale, and in another a drift was driven into a large mass of shale, and explosions occurred. He thought that as they got deeper they would have to take more care.

The PRESIDENT: What kind of shale?

Mr. LIDDELL: I call it carboniferous shale, as there is some coal in it.

The PRESIDENT: Not bituminous.

Mr. LIDDELL: Whether it belongs to the Carboniferous series I do not know.

The PRESIDENT: No.

Mr. WILLIS said that four or five years ago at the Fallowfield Lead Mine five men were burnt by gas from an adjoining coalfield. There was a very large trouble in the coalfield, which seemed to throw the lead measures to about their level.

The SECRETARY: There are coal seams among the actual bed of Fallowfield Lead Mine.

Mr. WILLIS: Yes, and there was no difficulty in connecting the gas in that case.

The SECRETARY: Not if it came from the coal.

Mr. BELL: The cases mentioned in this paper might be multiplied twenty-fold.

The PRESIDENT said that, as a general abstract question, they did not expect to find gas in metalliferous mines, but when it was found, he thought it would be invariably found it was owing to the close proximity to some bituminous matter, whether it be shale or coal. Mr. Bell had spoken of some lead mines, and it was known that seams of coal were connected with them. He hoped Mr. Brough would be present at the adjourned discussion.

On the motion of the PRESIDENT, seconded by Mr. WHITE, a vote of thanks was passed to Mr. Brough.

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Mr. T. J. Murday, of Felton, attended the meeting and exhibited and described a new apparatus, applicable to mines, for obtaining readings from indicators placed at a distance by means of electricity.

He showed how the reading of a distant aneroid barometer can be accurately recorded at the place where the "home" apparatus is placed. He stated that the invention may be used to obtain the readings of any form of indicator in use, from any distance—up to three or four thousand miles. In Meteorology the principle can be applied to the reading of either aneroid or mercurial barometers, metallic thermometers, anemometers, wind vanes, rain gauges, &c.; also in a similar manner, to recording the indications of gas or water meters, steam gauges, or any form of pressure gauge in ordinary use. The readings can be automatically recorded if required. The invention can also be usefully applied to read the indications of the various indicators in common use in coal and lead mines. All the instruments in a mine might be read, and the readings might be registered, in the manager's office above ground; thus showing him the actual condition of the workings below at any given moment.

# PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 13TH, 1889.

Mr. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The scheme for the Federation of Mining Institutes, as adopted by the Council, was formally laid before the members, and unanimously confirmed.

Notice was given of a series of alterations of the Bye-Laws of the Institute, proposed by the Council, and the consideration of which would, according to the existing rules, take place at a future General Meeting.

The following gentlemen were elected, having been previously nominated :—

ORDINARY MEMBER—

Mr. CHARLES BLAGBURN, Engineer, 150, Leadenhall Street, London, E.C.

ASSOCIATE MEMBERS—

Mr. JAMES BISHOP, Manager of the Grey Valley Coal Company's Collieries, Brunnerton, Greymouth, New Zealand.

Mr. THOMAS BROWN, Manager of the Westport Coal Company's Coalbrookdale Collieries, Westport, New Zealand.

Mr. WILLIAM CRAWFORD, M.P., North Road, Durham.

Mr. KENNETH MACRAE DAVIS, Mining Engineer, Ryton, Co. Durham.

Mr. CHARLES EDWARD FLEMING, Engineer, Gateshead-on-Tyne.

Mr. CHARLES WARREN ROBERTS, Assoc. M. Inst. C.E., Manager of Llechwedd Slate Mine, Plâs Weunydd, Blaenan Festiniog, North Wales.

Mr. SAVILLE SHAW, Demonstrator in Chemistry in the Durham College of Science, Newcastle-on-Tyne.

Mr. WILLIAM MARTIN SHORE, Manager of the Kaitangata Railway and Coal Company's Collieries, Kaitangata, Otago, New Zealand.

Mr. A. H. MEYSEY-THOMPSON, Engineer, Sun Foundry, Leeds.

The following gentlemen were nominated :—

ORDINARY MEMBERS—

Mr. FRANCIS COULTHARD, Arica Villa, Fox House, Whitehaven.

Mr. JAMES ROUTLEDGE JACQUES, Callio Villa, Whitehaven.

Associate Members—

Mr. Lancelot Wilkinson Chicken, Boldon Colliery.
Mr. Thomas Hall, Aberaman Colliery, near Aberdare, South Wales.
Mr. A. Mayon Henshaw, Talk-o'-the-Hill Collieries, Stoke-upon-Trent.
Mr. Henry William Hollis, North Lodge, Darlington.
Mr. John Plummer, Bishop Auckland.
Mr. John Henry Proctor, 29, Side, Newcastle-on-Tyne.
Mr. Hugh Sidney Streatfield, The Limes, Sergham Court Road, Streatham.

Students—

Mr. John Evelyn Carr, Cowpen Colliery, Blyth, Northumberland.
Mr. Frederick William Hall, Ryhope Colliery, Sunderland.
Mr. Norman Smith, The Bank, Haydon Bridge.
Mr. John Wood, Coxhoe Hall, Coxhoe.

The following paper was read :—

# PROCEEDINGS.

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Mr. A. H. MEYSEY-THOMPSON, Engineer, Sun Foundry, Leeds.

STUDENT—

Mr. T. PATTERSON, Silksworth Colliery, Sunderland.

The following gentlemen were nominated :—

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Mr. FRANCIS COULTHARD, Arica Villa, Fox Houses, Whitehaven

Mr. JAMES ROUTLEDGE JACQUES, Callio Villa, Whitehaven.

ASSOCIATE MEMBERS—

Mr. LANCELOT WILKINSON CHICKEN, Boldon Colliery.
Mr. THOMAS HALL, Aberaman Colliery, near Aberdare, South Wales.
Mr. A. MAYON HENSHAW, Talk-o'-the-Hill Collieries, Stoke-upon-Trent.
Mr. HENRY WILLIAM HOLLIS, North Lodge, Darlington.
Mr. JOHN PLUMMER, Bishop Auckland.
Mr. JOHN HENRY PROCTOR, 29, Side, Newcastle-on-Tyne.
Mr. HUGH SIDNEY STREATFIELD, The Limes, Leigham Court Road, Streatham.

STUDENTS—

Mr. JOHN EVELYN CARR, Cowpen Colliery, Blyth, Northumberland.
Mr. FREDERICK WILLIAM HALL, Ryhope Colliery, Sunderland.
Mr. NORMAN SMITH, The Bank, Haydon Bridge.
Mr. JOHN WOOD, Coxhoe Hall, Coxhoe.

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The PRESIDENT: The next question is that of the Federation of Mining Institutes. The Secretary has a few notes of the leading features of the federation, which I will ask him to read.

The SECRETARY read the following recommendations of the joint meetings of the representatives of the North of England Institute of Mining and Mechanical Engineers; Midland Institute of Mining, Civil, and Mechanical Engineers; Chesterfield and Midland Counties Institution of Engineers; South Staffordshire and East Worcestershire Institute of Mining Engineers; and North Staffordshire Institute of Mining and Mechanical Engineers:—

1.—The name of the Federation shall be "The Federated Institution of Mining Engineers."

2.—The objects of the Federated Institution of Mining Engineers are as follows:—

A. Publishing.
B. Appointment of Committees for experimental research.
C. Communication with the Government in cases of contemplated legislative action of a scientific character that interests or affects mining.

3.—Members shall be subscribers and Honorary Members of the Federated Institutes (see clauses 11 and 15).

4.—A Council shall be elected annually as the General Council of the Federated Institution by and out of each Institute in the proportion of one member of Council to fifty members of the Institutes. The Council shall, at their first meeting, proceed to add ten gentlemen to their number, to be selected from each Federated Institute in the same proportion.

5.—A President of the Federated Institution shall be elected each year at the Annual General Meeting, and shall not be eligible for re-election for one year.

6.—Each President shall continue during membership of one of the Federated Institutes an *ex-officio* member of the Council.

7.—One Vice-President shall be elected by and from the Council for each district for each 200 Associated Members.

8.—The Council shall appoint from its number a Committee of Selection of papers for publication. Such Committee to consist of one representative from each Institute, the selection subject to approval of the Council.

9.—The Council shall be empowered to frame, from time to time, Bye-laws for the proper carrying out of the objects of the Federation.

10.—General Meetings shall be held in one of the affiliated districts in January, July, and September, and an Annual General Meeting shall be held in London in April in each year.

11.—Each Associated Member shall have access to, and take part in, the General Meetings of the individual Institutes and of the Federated Institution. He shall also receive the Transactions and Proceedings of the Federated Institution.

12.—A discussion shall be opened *pro formâ* in each district on each paper, and, if thought necessary, a special discussion may be called for by the President of any district where an important discussion is likely to arise, and the author invited to attend. The final discussion at the Institute where the paper has been read shall be deferred until all the other discussions are closed, so that the author may be able to reply to all.

13.—Publications :—These shall be in two forms, viz. :—

A. *Transactions:* Comprising important papers having permanent interest.

B. *Proceedings:* Cheaper form of publication similar to the Bulletins of the French "Société de l'Industrie Minérale" for the remaining papers.

14.—The discussions shall be printed in the "Proceedings," unless important new matter is introduced which may be published in the "Transactions," at the discretion of the Federated Council.

15.—Each of the Federated Institutes shall pay 15s. per Associated Member into a General Fund to defray the expenses of publication and of the Federation. But the local institutes shall receive copies of their own portions of the publications in respect of such of their members as do not become members of the Federated Institution, and shall pay 10s. 6d. to the Federated Institution in respect of each such non-associated Member.

16.—The Secretary of each Institution shall edit the papers of that Institute.

17.—As it may be necessary to have one responsible General Editor, that Professor Lebour be appointed Honorary Secretary and Editor for one year.

18.—The Federated Institution shall commence on the 1st July, 1889.

The PRESIDENT: Having no doubt whatever in my own mind as to the advisability of a Federation of Mining Institutes, I have the greatest pleasure in moving from the chair that you authorise the Council to carry out the scheme.

Mr. G. B. FORSTER: I have much pleasure in seconding the resolution.

Agreed to unanimously.

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The PRESIDENT: The next question is the alteration of the Bye-laws of this Institute, and the Secretary will give you an epitome of the proposed alterations.

The SECRETARY read the particulars of the proposed alterations of the Bye-laws, the most important being as follow:—

1. The North of England Institute of Mining and Mechanical Engineers shall consist of Members, Associate Members, and Honorary Members. The Institute shall in addition comprise Associates and Students.

3. *Members.*—Every candidate for admission into the class of Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-three years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage he must have been employed or have practised as an Engineer for at least five years. This class shall also comprise every person who was an Ordinary Member, Life Member, or Student on the first of August, 1877.

4. *Associate Members* shall be persons connected with or interested in Mining or Engineering, and not practising as Mining or Mechanical Engineers, or in some other branch of Engineering.

5. *Honorary Members* shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6. *Associates* shall be persons acting as Under-Viewers, Under-Managers, or in other subordinate positions in Mines, or employed in analagous positions in other branches of Engineering.

7. *Students* shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or other branch of Engineering, and such persons may continue Students until they attain the age of twenty-five years.

16.—The annual subscription of each Member and Associate Member shall be £2 2s., of each Associate and Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

Mr. BENSON: Will an under-manager holding a certificate as manager, be eligible as an Associate?

The SECRETARY: There is nothing to prevent him becoming an Associate.

The PRESIDENT: I do not think the fact of a man holding a certificate as manager, if there is some person above him, will prevent him being eligible as an Associate. We must trust a good deal to the pride of a man to wish to become a Member, and not an Associate.

Mr. BENSON: There are many certificated managers who would pay one guinea rather than two guineas.

Mr. G. B. FORSTER: They will come in as under-viewers.

It was resolved, on the motion of the PRESIDENT, that the proposed alteration of the Bye-laws should be considered at a Special General Meeting to be held on June 8, next ensuing.

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Mr. CHARLES Z. BUNNING read the following paper on "Coal Mining at Warora, Central Provinces, East India":—

# COAL MINING AT WARORA, CENTRAL PROVINCES, EAST INDIA.

CHARLES Z. BUNNING, M.E., F.G.S., Assoc. M. Inst. C.E., M. Inst. M.E., & M. American Inst. Min. Eng.

The Warora Colliery, worked by the Government of India through the Local Government of the Central Provinces, lies almost in the centre of India. Its position, geographically, may be stated to be 20° 45′ north latitude, and 79° 5′ east longitude. Warora Colliery forms the terminus of the Wardha Coal State Railway, which joins the Great Indian Peninsular Railway at Wardha Junction. The latter railway runs to Bombay, the distance from Bombay to Warora by rail being, roughly, 500 miles to Wardha, plus 50 from Wardha to Warora, the whole journey occupying at present about 30 hours, by passengers in mail trains.

The colliery lies near the northern limit of the Wardha-Pranhita-Godaveri basin, and is known as the Wardha or Chanda Coal-field, a coalfield which extends south along 70 miles in the valley of the Wardha River, and in that distance averages 14 miles in width, and may be said to occupy an area of 1,600 square miles.

## GEOLOGICAL FEATURES.

The Wardha Valley Coalfield lies in the Northern division of the largely distributed system of rocks known as the Gondwana system, the coal-bearing rocks of India, a term derived from the name formerly given to the countries lying in the Central Provinces south of the Nerbudda Valley, embracing the divisions now known as the Jabalpore, Nagpore, and Chattisgarh, and which were inhabited by the Gonds, one of the principal Dravidian or aboriginal tribes of India, who occupied the country before the coming of the Aryan Hindu race.

To the North-East, the overlying Deccan trap covers the formation; to the North-West, metamorphic rocks are found; while to the South-West, shales and limestones of the Lower Windhyan form a boundary.

The correlation of this system with European systems is difficult to arrive at in view of the present imperfect geological knowledge of intervening countries, but it may be said that Indian geologists agree that the system ranges from the Permian to Upper Jurassic; hence, it is of a later origin than the principal coal-bearing or Carboniferous rocks of Europe. This determination of age is based principally upon palaeontological grounds.

The Gondwana system is made up of fluviatile deposits, and is characterised by a singular poverty of organic remains.

Before going on to describe the coal deposits in particular of the Wardha Coalfield, it will be best to describe the sub-divisions of this extensive system. First, geologists recognise two great sub-divisions, the Upper and Lower Gondwana. The Lower Gondwana contains the coal deposits of the Wardha Valley in the group of rocks known as Barakars, below which lie the Talchirs, the lowest group of the system, and above which lie the Kampthis, the remaining group of the sub-division.

The Talchirs are disposed of by saying that they consist of fine silty shales of a greenish grey or olive colour, and fine soft buff sandstones of a greenish tinge. A boulder bed frequently occurs amongst the shales and fine sandstones, consisting of boulders brought from a distance by glacial action. This series of rocks is coal-bearing only at Kurhubari in Bengal.

The Talchirs have not been found to exceed 800 feet in thickness, when they are found fully developed, as in the Raniganj Coalfield. In the Wardha Valley their thickness may be put down at about 500 feet, and they occupy 250 square miles of the Wardha Coalfield.

Next in ascending order comes the Barakar group, comprising the coal-bearing rocks of the Wardha Valley Coalfield. This group derives its name from a river which traverses the Raniganj Coalfield.

Its petrological features are beds of conglomerate, sandstones of various kinds, shales and coal. In the coalfield under notice, Mr. Hughes has never found the thickness of these rocks to exceed 250 feet, while in Bengal, when fully developed, they reach a thickness of 3,300 feet. Flexible sandstone occurs in these deposits.

At Warora these rocks lie generally as follows:—Firstly, in

descending order, three seams of coal, of which the lower two are thick; secondly, sandstones and shales; thirdly, a few thin carbonaceous beds; and fourthly, sandstone and shales.

Coal in the Wardha Valley is not likely to be found in any other group.

The next ascending group of rocks is known as the Kampthis, the name being derived from a military station of that name, twelve miles N.E. of Nagpur. These rocks consist of sandstones, clays, and conglomerates, of which the two former preponderate. At the base of these are coarse-grained sandstones, porous and pliable, yellow, reddish, brown, or grey in colour. These sandstones reach 400 to 500 feet in thickness. Above them come grits, with conchoidal fracture, and ringing under the hammer. The upper portions consist of coarse sandstones, grits, and conglomerates, in which beds, very ferruginous in character, are found. Manganese is found at Malagarh Hill, west of Kawassa, in botryoidal masses of red clay, containing no less than 44·6 per cent. of oxide of manganese.

The Kampthis lie unconformably upon the Barakars, and in many cases overlap them when the coal seams disappear. This group is devoid of coal, and is most extensively developed in the Wardha Valley Coalfield, occupying several hundred square miles without a break on the east side of the Wardha River, over almost two-thirds of the area under notice.

Next in ascending order comes the Kota-Maleri group of the Upper Gondwana system, the names Kota and Maleri being derived from the names of two villages in the Central Provinces. Red and green clays, with soft white and greenish argillaceous sandstones, form the principal beds of this group. The group is imperfectly known in the Wardha Valley Coalfield. These rocks are about 1,500 feet thick, and are unconformable to the Kampthi beds.

The above four groups, Talchirs, Barakar, and Kampthis of the Lower Gondwana, and the Kota-Maleri of the Upper Gondwana, are the only groups of the Gondwana system which are exposed in the Wardha Coalfield.

At Warora, the Kampthis are covered with alluvium, varying from 20 to 30 feet in thickness. The absence of any hard rock for the first 20 to 30 feet makes it a matter of great difficulty to secure good foundations for new buildings. The soil consists of a tenacious, brown, blackish clay, known as black soil, or black cotton soil. It admits water readily, and expands and contracts to a remarkable

degree under the influence of moisture and dryness. Nodules of Kunker are found in a tenacious brown clay. Kunker is the term applied here to the small concretionary nodules composed principally of carbonate of lime, mixed with silica and alumina. All the lime used for building purposes is derived from this source, which is found to give rise to a cement which is rather hydraulic in character.

The other groups of the Gondwana series are not exposed in the Wardha Coalfield. Igneous outbursts of rock are entirely wanting; trap is found, but is everywhere the result of injection, not of eruption.

In describing the neighbouring tracts of coal in the Northern portion of the Wardha, Pranhita, or Godaveri basin, the first one, or northernmost one, is the Bandar Coalfield (see plate I.) situated about 32 miles, almost due west of Hinganghat Station, on the Wardha Coal State Railway, and lying near the village of Chimmur.

Coal has here been proved by borings at a very moderate depth, to the extent of 38 feet thick in three seams, of much the same quality as Warora coal. The area of coal-bearing strata is about five or six square miles. Eight bore-holes have been put down at depths varying from 168 to 302 feet, in all of which coal was proved. In the opinion of the author, this coalfield could be worked cheaper than at Warora, for the coal seams have all good sandstone roofs.

Next comes a small patch of Barakars, in which coal has not been found, between the villages of Bailgaum and Kandara. Nor was coal found further south, near Aikona, although there are strong indications of its existence, but it has not been properly prospected for.

Next comes the Warora tract, which is entirely covered by alluvium, and does not afford the slightest indication of coal. Geologists, in fact, said coal did not exist, but by some chance boring the mineral was discovered by Mr. Mark Fryar, in 1870, and Warora was at once chosen as the most convenient spot to work, coal being near to the proposed railway, from Wardha, which was projected to go to Chanda, to find an outlet for the then discovered coalfield near Ghugus, at which a colliery was opened and working. The field, as now proved here, is a very narrow strip, which may extend to Saimbal to the South. The Northern, Western, and Eastern limits have been defined. Further South, at Nanduri, no coal has been found. Again, going South, Majri is reached, where coal was proved at a depth of 75 feet, to the extent of 50 feet, including

partings, dipping 12 degs. over an area of three square miles. At Kunara, again further South, a borehole proved no coal, and this was also the case at Agasi.

At Telwasa, three seams of coal were found in the river, at a depth of 61 feet, aggregating a thickness of 58 feet. Mr. Hughes says this area is too small for practical utility. An analysis of the coal gave from 18 to 22·91 per cent. of ash, 32·00 to 33·15 per cent. of volatile matter, and 43·94 to 50 per cent. of carbon.

Further South is found the Ghugus Coalfield, the earliest discovered coal in the Wardha, Pranhita, and Godaveri basin. A pit was sunk here, 121 feet deep, and coal found 38 feet thick, with partings. This pit was formally opened by Lord Mayo, then Viceroy of India, in 1870, and the colliery bears his name to this day. Seventy tons a month was raised here, and tried on the Great Indian Peninsular Railway. The pit was abandoned when coal was found at Warora. Coal 90 feet thick was proved at Nokora, in the same basin. The dip of the seam at the Mayo Pit was 8 to 12 degs., and little water was found in sinking. The area of the Ghugus field is about three square miles, and Mr. Hughes estimates that there is about 90 million tons of coal, of which half is available.

The strip of coalfield, lying West of Ghugus, between Junara and Chicholi, is about five square miles in area, containing 150 million tons of coal, of which 75 million tons are available.

The largest tract of coal in the Wardha Valley is that known as Wun, which has been proved by many boreholes, and a sinking.

Wun lies on the West side of the Wardha, in the Berars, a province belonging to the Nizam of Hyderabad, but governed and managed by the British Government. Coal was discovered at Zagra. At Pisgaon, the site of a colliery, coal was first found by a borehole, 77 feet deep, 27 feet thick. A sinking was commenced in 1871, and in 1873 another pit, 9 feet in diameter, was sunk and proved coal at 108 feet deep, 21 feet thick. This colliery was abandoned after 150,000 rupees had been spent, as coal having been found at Warora, it was nearer the proposed railway, and, besides, was on Government property; for if Pisgaon had been opened in preference, royalty on the coal raised would have been due to the Nizam of Hyderabad. At this colliery to this day, all the machinery, consisting of a winding engine, pumping engine, heapstead, and other small things, is kept in good order and ready for use. Coal has been found at Parsora, 31 feet thick, and at other places between

there and Papur, thus proving a large area of coal. Even at Wun, coal was proved at a depth of 300 feet, 32 feet thick.

The area of the Wun basin is about 11 square miles, that is the portion lying between Wun and Papur, and contains, according to Mr. Hughes, 105 million tons of coal, of which 50 million tons are available. The district around Wun contains, according to the same authority, 2,100 million tons, of which 1,500 million tons are available; and the coalfield covers an area of about 80 square miles.

In the neighbourhood of Chanda coal has been bored for, but none found.

South of Chanda, in the Nizam's dominion, coal is again met with at Sarti. Borings were made there from 1871 to 1874. Two shafts were sunk near Sarti, 80 to 90 feet deep, in which coal was found, including bands, 27 feet thick.

This coal was analysed, and gave—

| | Sample 1. | Sample 2. |
|---|---|---|
| Fixed carbon ... ... | 51·2 | 49·9 |
| Volatile matter ... ... | 39·0 | 42·4 |
| Ash ... ... ... | 9·8 | 7·7 |

The quantity of ash is under the average of Indian coals. The area of the coalfield is about 1 square mile, and it contains 60 million tons of coal, of which 20 million tons are available.

Further South, coal has been found at Anterjaon, but not by borings. This basin, therefore, remains at present unproved in area.

According to Mr. Hughes, whose papers have supplied me with a large portion of the geological information here detailed, the foregoing areas are summarised as follows:—

| | Actual Quantity. Tons. | Amount Available. | Square Miles. |
|---|---|---|---|
| Warora Basin ... ... | 20,000,000 | 14,000,000 | $\frac{2}{3}$ |
| Ghugus ... ... ... | 90,000,000 | 45,000,000 | 3 |
| Wun ... ... ... | 2,100,000,000 | 1,500,000,000 | 80 |
| Between Wun and Papur... | 105,000,000 | 50,000,000 | 11 |
| Between Junara & Chicholi | 150,000,000 | 75,000,000 | 5 to 6 |
| Sarti and Paoni Basins ... | 60,000,000 | 30,000,000 | 1 |
| | 2,525,000,000 | 1,714,000,000 | $101\frac{2}{3}$ |

The Wardha-Pranhita-Godaveri Coal Basins stretch over 11,000 square miles, almost one-third of the total area of coalfields in India, and constituting the largest continuous area.

## PHYSICAL GEOGRAPHY.

Warora lies in an extensive plain, which forms the very level valley of the Wardha. Towards the north extends scrubby jungle, with cultivated patches lying near the scattered villages. Towards the west the plain is more or less cultivated, and reaches into the Berars. To the east it is less covered with jungle than in the north, and towards the south, after some miles of cultivated ground, comes the large forest area of Chanda. A few isolated hills of moderate height, consisting of undenuded patches of basaltic trap, break the weird monotony of the plain.

Jawari and wheat are extensively cultivated, together with linseed oil.

The annual rainfall at Warora varies from 33 to 60 inches. The latter is considered a very heavy fall, and is looked upon as phenomenal. The rain chiefly falls during the latter half of June, in July, August, September, and first half of October. The rainfall of Warora is less than that of the surrounding districts.

| | | | | | |
|---|---|---|---|---|---|
| In 1885 it reached | ... | ... | ... | 54·81 | inches. |
| „ 1886 „ | ... | ... | ... | 46·53 | „ |
| „ 1887 „ | ... | ... | ... | 58·38 | „ |
| „ 1888 „ | ... | ... | ... | 40·00 | (about) |

In October the weather is still unpleasant, owing to the heat bringing out the moisture of the ground. The temperature during this period seldom exceeds 85 degs. Fah. in the shade during the day. November, December, and January are pleasant months, the temperature in the shade never reaching more than 75 degs. Fah. during the day. During February, March, and April the heat increases, but the nights are cool, while in May and June the temperature reaches 110 to 115 degs. Fah. in the shade during the day, and at night never falls much below 90 degs. Fah.

During the months of March, April, May, and beginning of June the heated atmosphere is intensely dry, while during the monsoon weather it is just as intensely damp.

The effect of the climate upon Europeans and natives is rather severe, fever being rife during the rainy months and the beginning of the cold season, when the ground is drying and giving off malarial germs. Pit work, combined with the climate, has the effect of decolourising the blood and a general weakening of the system, anæmia being what may be termed the trade sickness or endemic of the miner, brought on by bad ventilation and malaria. Cases of

enlarged spleen are frequently met with. Cholera occurred in 1882, when many deaths took place, and also, in 1887, attacking with fatal results many natives and one European.

## HISTORY.

The early history of Warora coal is confined to very recent years. In 1831 attention was first called to coal found on the banks of the River Wardha. Active operations were only commenced in 1870, when coal was found quite accidentally, and bore-holes were put down in the neighbourhood of Warora. Before that time, Chanda was looked upon as the most likely source of coal for the Great Indian Peninsular Railway, and the railway then projected, and now known as the Wardha Coal State Railway, was to have been pushed on to Chanda to the colliery, there established in 1870 at Ghugus. In fact Warora was not known to possess coal, as the coal-bearing rocks there are not exposed. In 1873 the No. 1 Pit at Warora struck coal on July 20 at 180 feet, and No. 2 Pit was commenced. Coal having been found, a colliery was established, but not without difficulties, for in the No. 1 Pit, 190 feet deep, heavy feeders of water were met with, and the pumping engines required, though of no great magnitude, assisted to swell the capital account of the colliery, which is at present far more than the capital which would be now requisite for a colliery in the district opened out under competent men. The pioneer colliery must always be an expensive one, for the labourer unaccustomed and untrained to mining will be difficult to manage, and the scant information of the work ahead makes the necessary precautions against possible difficulties uncertain.

## COAL.

Coal is at present found at depths varying from 100 to 300 feet in three seams, of which the first does not extend over the whole area, where towards the rise it seems to be denuded. Towards the dip, this seam, called No. 1, is hardly a true coal seam; it consists of a soft, black shale resembling more a mudstone than a coal, there being no discernable layers of stratification or lamination such as are generally seen in coal or shale. It is still possible that in yet unexplored areas more to the dip, No. 1 Seam may become a coal seam in fact as well as in name, but this is very

improbable. No bore-holes as yet put down prove it. The nature of this so-called No. 1 Seam is rather soft when met with in sinking. About 14 feet below it is found No. 2 Seam, varying from 14 to 17 feet in thickness. The coal in this seam would be considered by an English miner of the North of England, or South Wales, as shale with thin streaks of true coal interspersed; varying in thickness from nothing to a foot. Below this seam comes from 4½ to 7 feet of shaly sandstone, and then No. 3 Seam of about the same average thickness as No. 2 Seam.

Immediately beneath No. 3 comes a hard white micaceous sandstone, below which only thin bands of coal from about 3 inches to 18 inches thick are known to occur.

The coal of No. 3 Seam is similar to that of No. 2 Seam, except that in the former the thin bands of true coal are still thinner. It is very difficult to find an uninterrupted thickness of true coal in the No. 3 Seam of more than 8 inches to 9 inches.

An analyis of No. 2 Seam gave, according to Mr. Tween, of Calcutta, the following result :—

| | | | |
|---|---|---|---|
| Fixed Carbon ... ... | 45·4 | | Per Cent. |
| Combustible volatile matter | 26·5 | Sulphur in coal | 2·85 |
| Water expelled at 212 degs. Fah. | 13·9 | | |
| Ash ... ... ... | 14·2 | | |
| | 100·0 | | |

Mr. Hughes, in his report on the Wardha Valley Coalfield, gives two interesting analyses of the upper portion of No. 2 Seam, one of the dull shaly splints, and the other of the bright, the latter resembling more in appearance the true coal of the Carboniferous age.

| | Dull Splint Coal. | Bright Coal. |
|---|---|---|
| Fixed Carbon ... ... ... | 57·0 ... | 48·0 |
| Volatile combustible matter ... | 28·5 ... | 38·0 |
| Ash ... ... ... ... | 14·5 ... | 14·0 |
| | 100·0 | 100·0 |

Of coal, sent to England by the Government of India, various analyses have been made by Messrs. Snelus and Riley.

Two samples of coal crushed in a Carr's disintegrator, analysed by Mr. Snelus, gave—

| | One Sample. | A more correct average sample. |
|---|---|---|
| Carbon ... ... | 41·74 ... ... | 42·08 |
| Volatile matter ... | 38·95 ... ... | 37·85 |
| Sulphur ... ... | 2·21 ... ... | 1·87 |
| Ash ... ... ... | 17·10 ... ... | 18·20 |
| | 100·00 | 100·00 |

This disintegrated coal was washed down a streamer 100 yards long with a good body of water. The washed coal yielded :—

| | |
|---|---|
| Carbon (fixed) ... ... ... ... ... | 46·91 |
| Volatile matter ... ... ... ... ... | 36·65 |
| Sulphur ... ... ... ... ... ... | 0·74 |
| Ash ... ... ... ... ... ... | 15·70 |
| | 100·00 |

A sample of the pyrites and earthy matter removed by washing from the coal yielded :—

| | | |
|---|---|---|
| Carbonaceous matter ... ... ... | 15·00 | |
| Insoluble earthy do. ... ... ... | 18·20 | |
| Metallic iron ... ... ... ... | 22·61 | pyrites. |
| Sulphur ... ... ... ... ... | 24·08 | |
| | 79·89 | |

Washing then will remove a large part of the sulphur, but not the earthy matter, the ash after washing still constituting a high percentage.

Endeavours to coke the coal have resulted in absolute failure. Mr. Snelus burnt some in a beehive oven, and it was found that the coal had not coked in the slightest, nothing but a sandy heap being left. Even when the coal was mixed with 25 per cent. of bituminous coal and coked as before, no better results were obtained.

Less encouraging even were the results recorded by Mr. W. Hackney, who made a report, in 1879, to the Indian Government, on the iron ore and coal from the Wanda district of the Central Provinces of India. Mr. Hackney tried mixing the coal with pitch, and coking coal from the Llyndu Colliery, near Bridgend, in various proportions, and only when Warora coal was mixed with 50 per cent. of Llyndu coking coal, did a tolerable coke result, but as Mr. Hackney continues to say, "not fit to bear a great weight in a blast furnace."

In India, experiments were again made to coke the coal in 1881-2, and results obtained which conclusively proved that Warora coal would not yield a coke.

One more analysis remains to be quoted—that made by Mr. E. Riley, in 1878, from an average sample of No. 2 Seam.

| | |
|---|---|
| Moisture driven off at 212 degs. Fah. ... ... | 11·00 |
| Volatile carbonaceous matter ... ... ... | 31·64 |
| Fixed carbon ... ... ... ... ... | 43·42 |
| Ash ... ... ... ... ... ... | 13·94 |
| | 100·00 |
| Sulphur per cent. ... ... ... ... | 1·15 |

Another analysis made of No. 2 Seam in 1882, after the seam had been more opened out, is given :—

| | Large Coal. Per Cent. | | Slack Coal. Per Cent. |
|---|---|---|---|
| Fixed carbon ... ... ... | 45·6 | ... | 35·5 |
| Volatile matter, combustible ... | 26·0 | ... | 26·4 |
| Volatile matter, uncombustible ... | 14·0 | ... | 13·0 |
| Ash ... ... ... ... | 14·4 | ... | 24·0 |
| | 100·0 | | 98·9 |

In 1883, when No. 3 Seam was opened out, analyses were made of this seam by Mr. Warden, of Calcutta—all the preceding analyses are of No. 2 Seam—with the following result :—

| | Top of No. 3 Seam. | Middle of No. 3 Seam. | Bottom of No. 3 Seam. |
|---|---|---|---|
| Moisture at 115 degs. Fah.... | 11·99 | 10·54 | 14·65 |
| Ash ... ... ... ... | 19·70 | 23·85 | 14·26 |
| Sulphur ... ... ... | 1·68 | ·86 | ·88 |
| Coke, inclusive of Ash ... | 61·02 | 62·95 | 54·42 |
| Volatile matter, inclusive of water and part of the sulphur ... ... ... | 38·98 | 37·05 | 45·58 |

None of the samples coked.

Deducting from the coke the ash, and from the volatile matter the moisture and sulphur, the analyses become—

| | | | |
|---|---|---|---|
| Moisture ... ... ... | 11·99 | 10·54 | 14·65 |
| Ash ... ... ... ... | 19·70 | 23·85 | 14·26 |
| Sulphur ... ... ... | 1·68 | ·86 | ·88 |
| Coke (fixed carbon)... ... | 41·32 | 39·10 | 40·16 |
| Volatile matter (combustible) | 25·31 | 25·65 | 30·05 |
| | 100·00 | 100·00 | 100·00 |

All the foregoing commercial analyses will show clearly the value of the coal. The differences of the analyses may be accounted for by the coal being thick, and consisting of bands of dull or stony coal, mixed with bands of bright coal, but not evenly distributed throughout the seam; hence, some portion of the mineral, when analysed, may have contained a greater or less amount of bright coal, thus accounting for the different percentages of ash and fixed carbon.

In 1884, when No. 3 Seam was the most extensively worked of the two seams, complaints were made by consumers of the dull, stony coal, of which, in No. 3 Seam, there is a band of an average thickness of a foot, containing no layers of bright coal, and which, it was said, made too much ash, and was inferior to the average quality of Warora coal. Early in 1885, the Chemical Examiner to the Government of India in Calcutta—Dr. Waddell—made the following ultimate analyses of No. 2 Seam, No. 3 Seam, and the dull, stony coal of No. 3 Seam. The writer collected the samples, and they were fair average samples. No. 2 Seam sample, containing the bright streaks of coal already referred to; No. 3 Seam, a lesser quantity of such streaks, and the No. 3 Seam stony band no bright coal at all:—

| | No. 2 Seam. | No. 3 Seam. | No. 3 Seam, Stony Coal. |
|---|---|---|---|
| Moisture ... ... | 12·24 | 12·09 | 7·67 |
| Ash ... ... ... | 10·36 | 14·18 | 47·40 |
| Carbon ... ... ... | 47·00 | 47·972 | 26·17 |
| Hydrogen ... ... | 5·60 | 3·45 | 2·62 |
| Nitrogen ... ... | Trace | 1·63 | Trace |
| Oxygen ... ... | 23·689 | 19·428 | 15·63 |
| | 98·889 | 98·750 | 99·49 |

Taking the theoretical calorific power of No. 2 Seam as 1000, the No. 3 Seam is represented by 903, and the stony coal of No. 3 Seam by 498. It will be also seen that No. 2 Seam is the best as a commercial fuel, containing less ash than the others.

The percentage of oxygen is very high in Nos. 2 and 3 Seams, and this might lead one to take them for lignites, but of an inferior quality, for lignite generally contains more than 60 per cent. of fixed carbon. Generally stated it may be said that the coal is bituminous and of a laminated structure, consisting of bands of shale and thin bands of bright, true coal, of which, however, the former predominates. There is no doubt that the quality of the

coal could be improved, were it desirable, by picking out the dull shaly coal, and selling only the bright coal, after carefully washing it; but it would add very much to the cost of the fuel.

Compare with these analyses the following analysis of coal taken from Messrs. Brown and Adam's paper on deep winning of coal in South Wales, Vol. LXIV. of the Proceedings of the Institute of Civil Engineers, and it will be seen how poor in comparison the Warora coal is, and as the coals of India, with the exception of the Karharbari (which is only equal to the poorer classes of English coal) are very little better, it shows that for ocean steamers and for smelting purposes the fuel is practically valueless:—

| | Per Cent. |
|---|---|
| Carbon ... ... ... ... ... ... | 88·59 |
| Hydrogen ... ... ... ... ... | 4·10 |
| Oxygen ... ... ... ... ... ... | 3·89 |
| Nitrogen ... ... ... ... ... | 0·27 |
| Sulphur ... ... ... ... ... ... | 0·62 |
| Ash ... ... ... ... ... ... | 1·76 |
| Water ... ... ... ... ... ... | 0·77 |
| | 100·00 |

This, however, does not detract from the value of the fuel in India, for, where there is no better, one must be content to use what one can get, so that, consequently, up country, where the distance from any ports makes English coal, on account of cost of carriage, prohibitive, Indian coal becomes a valuable fuel for railways, mills, and other purposes of local consumption. As a matter of fact, Warora coal is extensively used by the Great Indian Peninsular Railway, and by all fuel consumers of importance in the neighbourhood.

Returning to the composition of the Warora coal, it will be seen that the amount of fixed carbon is very deficient, so that, for the creation of high temperatures and for smelting, its value is small. The percentage of ash, too, is very great, no sample giving less than 13 per cent., except in one analysis which gave 10·36 per cent. of dirt, while it reaches sometimes 18 per cent. This large amount of ash causes some trouble in firing in locomotive boilers, necessitating extra large fire-boxes, and bars wide apart, and so great is the waste, that when the fires are cleaned almost all the fuel disappears, leaving a black grate.

The small coal, when used for firing, clinkers very much. The ash is of a grey colour.

An analysis of the ash from No. 2 Seam (made by W. E. Riley), after being heated in a close vessel, yielded:—

| | |
|---|---|
| Silica ... ... ... ... ... ... | 57·93 |
| Titanic acid ... ... ... ... ... | 0·80 |
| Alumina ... ... ... ... ... ... | 22·74 |
| Peroxide of iron ... ... ... ... ... | 8·71 |
| Lime ... ... ... ... ... ... | 6·04 |
| Magnesia ... ... ... ... ... ... | 1·29 |
| Potash ... ... ... ... ... ... | 0·94 |
| Phosphoric acid ... ... ... ... ... | 0·06 |
| Sulphuric acid ... ... ... ... ... | 0·51 |
| | 99·02 |

The sulphur occurs chiefly in lumps of pyrites, which appear occasionally in spangles on the surface of the coal. Washing and picking the coal would eliminate a large proportion of the sulphur.

The amount of moisture present is very great, the percentage being almost the same as that in lignite.

The physical nature of the coal is described by saying that it is exceedingly friable, weathering in a short time by splitting up into small prismatic fragments; but still clinging together in lumps, and resembles nothing better than wood charcoal. It is exceedingly liable to spontaneous combustion, not so much on account of the pyrites contained, as the great affinity this coal has for oxygen. The heat caused by this chemical action of oxidation will gradually raise the temperature of coal when lying in bulk, and more particularly the small coal, to an igniting temperature, and many heaps of stacked coal have thus frequently been lost at Warora Colliery. The absorption of oxygen is also the cause of the action of weathering by the coal, owing to the physical action of the oxygen increasing the bulk and so splitting the coal. It should be used freshly mined, and the Great Indian Peninsular Railway, in their contract with the Government, have a clause that the coal should be vended to them straight from the pit, and not from stacked portions on the surface.

At first great difficulty was experienced in selling this small coal, so that it was left underground, causing the colliery afterwards a large loss in the shape of an underground fire; but this will be noted later on. Attempts were made also to make patent brick fuel of the small, but without success, and as ultimately a large demand for small coal arose, no further attempts were made in this direction.

The coal, when examined in its bed, shows a distinct cleavage vertically running at right angles to the strike of the seam. The coal also, during the course of mining, tends to split up in horizontal lines. So-called "backs" or "breakers" occur in the coal, varying from 3 inches to 18 inches apart, but not running in one vertical plane. These breakers are vertical cracks—the result of pressure, no doubt, and greatly assist in working the coal. In South Wales the backs are very distinct, and lie at an angle of about 80 degs. with the vertical. The coal, consequently, at Warora is mined much more easily against the cleat, that is in the direction of the strike, which is the direction of the "bords" or wide galleries while the galleries at right angles to these are narrow, and are termed "headways"; and the coal has a great tendency to break up in rectangular blocks. When the system of mining is under notice, more details will be given. The coal in its bed is of an exceedingly tough and woody nature, making it rather difficult to mine.

The calorific power of the coal is equal to 7·7 lbs. of water evaporated by 1 lb. of fuel from 212 degs. Fah. Warora coal gives out a great heat during combustion, owing, no doubt, to the small amount of volatile hydro-carbons which it contains.

## FIRE-CLAY.

If the section of No. 5 Pit be referred to, it will be seen that fire-clay exists above No. 2 Seam 11 feet 3 inches thick, of which the lower 3 feet 9 inches is a pure white clay, which has been pronounced equal to English fire-clay. A specimen of this clay is on the table. It is not at present mined alone, but is got when required from falls and goaf of the broken workings of No. 2 Seam, No. 4 Pit. The demand for the clay is at present so limited that no special means of working this fire-clay seam has as yet been adopted. The sale wants pushing. At present, the clay costs under half-a-rupee a ton to get, and one rupee to grind, and it is sold at prices below the price of English clay at the place where it is required, making due allowance for the freight from Bombay and freight from Warora.

This clay should be made into bricks, for the ordinary bricks made at Warora are so bad, on account of the lime contained in the brick-earth, that it would be of great value to be able to make good and cheap bricks on the spot. This is a subject the writer has frequently submitted to the Government, but nothing has been done as yet.

## THE SUPERINCUMBENT STRATA AND COST OF SINKING THROUGH THEM.

A section of No. 5 Pit will have to be taken as a typical one, as no record exists—strangely enough—of the strata passed through in the earlier pits. No. 6 Pit was sunk too near the outcrop to be of any service in giving a typical section.

| | Ft. | Ins. | | |
|---|---|---|---|---|
| Black cotton soil ... ... ... | 4 | 9 | } Alluvium. | |
| Clay, mixed with kunker ... ... | 39 | 0 | | |
| Sandstone, soft ... ... .. | 1 | 6 | } Kampthis Group. | |
| Sandstone, hard red ... ... ... | 0 | 3 | | |
| Sandstone, reddish colour, coarse-grained ... ... ... .... | 15 | 3 | | |
| Sandstone, very soft ... ... ... | 2 | 0 | | |
| Sandstone, reddish coloured... ... | 15 | 3 | | |
| Sandstone, white, streaked with iron | 10 | 4 | | |
| Clay ... ... ... ... ... | 0 | 8 | | |
| Rotten sandstone ... ... ... | 2 | 4 | | |
| Sandstone, reddish ... ... ... | 13 | 8 | | |
| Sandstone, dark red ... ... ... | 3 | 0 | | |
| Sandstone, reddish, coarse-grained ... | 11 | 6 | | |
| White quartzose sandstone, rather hard | 2 | 0 | } Barakar Group. | |
| Coal seam No. 1, very poor ... ... | 1 | 7 | | |
| Seggar clay, dark in colour, soft ... | 7 | 6 | | |
| Seggar clay, white, harder and better in quality ... ... ... | 3 | 9 | | |
| Shale, black mottled... ... ... | 3 | 2 | | |
| Coal, No. 2 Seam ... ... ... | 17 | 0 | Ft. Ins. 154·6 | |
| Shale, black stony ... ... ... | 0 | 6 | | |
| Post girdles ... ... ... ... | 1 | 0 | | |
| Hard shale and coal, mixed in bands | 3 | 0 | 4·6 | |
| Coal No. 3 Seam ... ... ... | 16 | 3 | 175·3 | |
| 12 feet Sump, rest bored—Hard white micaceous sandstone ... ... | 50 | 0 | | |

None of the overlying beds are hard enough to render blasting in sinking a necessity. A sinking pick with wedges, with an occasional shot, is all that is required. Progress is slow. No. 6 Pit, 100 feet deep, was sunk in three months, and No. 5, the lower, 76 feet in 2½ months; the former is 15 feet diameter in the clear, with 18-inch brickwork walling and 6-inch concrete packing, while the latter is rectangular 6 feet by 10 feet, and strong enough to stand without

lining, except for the first 45 feet. The white micaceous sandstone below No. 3 Seam is fairly hard, though in England it would be thought a soft sandstone. The sinking hours are 8 hours a shift, and the men make from 5 annas to 6 annas a shift. Generally the sinking is done by contract.

No. 4 Pit to No. 2 Seam, 170 feet, cost 31,578 rupees, including head-gear and winding engine (16 horse-power Roby engine). The sinking of No. 1 Pit, and fitting up of engines and boilers, cost 65,343 rupees, 190 feet deep. The sinking of No. 5 Pit, 187 feet deep to the bottom of sump, cost 20,923 rupees. The sinking and lining of No. 6 Pit cost 10,000 rupees. The cost in detail is given below :—

COST OF SINKING No. 6 PIT.

| | ₹ | A. | P. |
|---|---|---|---|
| Sinking 110 feet deep, round, and 15 feet diameter in the clear ... ... ... | 1,482 | 6 | 10 |
| Tools, Stores, etc. ... ... ... ... | 173 | 4 | 11 |
| Walling 70 feet, with 18-inch brickwork... | 4,419 | 0 | 1 |
| Concrete packing behind walling ... ... | 449 | 11 | 9 |
| Erecting of sinking engine and boilers ... | 645 | 0 | 2 |
| Wrought teak-wood 81 cubic feet, in the shape of 3 walling curbs, and 110 props | 1,428 | 2 | 9 |
| Wrought ironwork ... ... ... ... | 383 | 15 | 0 |
| Contingencies: extra walling required, and sinking through very soft and fallen ground ... ... ... ... ... | 1,035 | 6 | 0 |
| | ₹10,016 | 15 | 6 |

The cost could have been reduced to 8,000 rupees, had it not been for the last 30 feet of very soft strata, which necessitated very careful sinking with timber lining and subsequent walling. There was no water to contend with, and no blasting was necessary.

No. 1 and 3 Pits were very expensive to sink, the labourers were unexperienced, the water was heavy, amounting to 500 and 600 gallons a minute, and the sandstone much harder than in the case of the other pits—the rocks get harder towards the dip.

COST OF BORING.

A very large number of boreholes have been put down near Warora, proving very conclusively the limits of the present patch of coal—it can only be called a patch, for its extension to the south is

where the bulk of the Wardha Valley coal lies. Fifteen years ago a few boreholes were put down on the Mather and Platt system, but that system fell into disuse, and the greater number of the holes have been bored by hand. They range from 100 feet to 350 feet. The last borehole put down by hand was in 1878, and went down 350 feet. The cost of the hole was 1,612 rupees, and it took 162 days to bore.

Recently, the author tried boring by steam on the Canadian principle, only instead of employing the rope generally used, he adopted rods. A rig of 65 feet was erected of teak timber, and it, together with Sampson post of teak timber, and all other fittings, cost 3,416 rupees, the timber alone costing 1,929 rupees. The price of teak-wood at Bombay for this rig ranged from 3 rupees 4 annas to 4 rupees per cubic foot. The cost of erecting the whole rig came to 257 rupees. The boring winch, which is a 5-ton steam winch, cost at Warora, together with two vertical boilers, 5,152 rupees. It is a well made winch, and was built after the design of the author, who wanted a special form of winch to draw the rods, lift the sand pump, and work the Sampson post lever, three operations requiring different speeds and powers. Messrs. Cowan and Co., of Carlisle, built it, and the whole rig was got to work on October 2nd, 1888. The total plant, therefore, costs 3,416 rupees.

| | | |
|---|---|---|
| Winch | ... ... | 5,152 |
| | | 8,568 rupees. |

A fresh set of boring tools for a 600 feet hole, replete with all kinds of tools for extracting broken rods and pipes were got, and cost at Warora 17,889 rupees.

As these two boreholes, viz., the one put down by hand above mentioned, and the one put down by steam, were driven in the same ground, that is through the same strata, and very bad strata too, consisting of soft running light green tenacious argillaceous clays of the Talchirs system (which form the beds below the coal-bearing rocks of the Barakars, at Warora), a very good comparison can be made of the relative cost and speed of hand and machine boring. The holes were put down to explore for coal to the dip; needless to say, coal was not found, and the following table will be instructive in this respect. The steam boring was put down in 66 days very nearly 300 feet, the depth at which it was when the author left India on 6th December, 1888.

### HAND BORING, 1878.

Working 3 shifts per day of 8 hours each :—

| | R. | A. | P. |
|---|---|---|---|
| 30 men per day at crab winch, at 4 as. ... ... ... | 7 | 8 | 0 |
| 6 men per day at tillers, at 4 as. | 1 | 8 | 0 |
| 3 mates at 10 rupees per month | 1 | 0 | 0 |
| 3 watermen at 4 as. ... .... | 0 | 12 | 0 |
| 3 tool sharpeners and pump cleaners, at 4 as. ... ... | 0 | 12 | 0 |
| 2 chowkidars (men in charge of tools), at 3½ as. ... ... | 0 | 7 | 0 |
| Total cost per day when boring, tubing, and fishing up tools | 11 | 15 | 0 |
| Cost per day when idle, 2 chowkidars, at 3½ as. ... | 0 | 7 | 0 |

### STEAM BORING, 1888.

Working 1 shift per day of 12 hours :—

| | R. | A. | P. |
|---|---|---|---|
| 4 boring coolies at 5 as. ... | 1 | 4 | 0 |
| 1 boy at 3 as. ... ... ... | 0 | 3 | 0 |
| 1 waterman at 4 as. ... ... | 0 | 4 | 0 |
| 1 engineman at 5 as. ... ... | 0 | 5 | 0 |
| 2 stokers at 5 as. ... ... | 0 | 10 | 0 |
| 2 chowkidars at 3½ as. ... | 0 | 7 | 0 |
| | 3 | 1 | 0 |
| Stores, 1 ton of coal at R3 3 0 | | | |
| Carrying to borehole 0 6 0 | | | |
| | 3 | 9 | 0 |
| Per cwt. | | | |
| 2 lbs. of castor oil at R16 8 0 | 0 | 4 | 9 |
| ½ lb. of tallow at 25 8 0 | 0 | 1 | 10 |
| 1 lb. of cotton waste at 15 8 0 | 0 | 2 | 2 |
| | 7 | 2 | 9 |
| Sharpening tools, 1 blacksmith ½ day's work at R1 per day | 0 | 8 | 0 |
| Total cost per day when boring, tubing, and fishing up tools ... .. ... ... | 7 | 10 | 9 |
| Cost per day when idle ... | 0 | 7 | 0 |

In neither case is the cost of chargeman included.

### SPEED OF BORING.

NOTE.—Tubing and fishing up boring tools counted as boring in both cases.

1 day = 24 hours.

| | | Per cent. | Rate per day. Ft. |
|---|---|---|---|
| 1st 100 feet took | 8¼ days ... | 100 | ... |
| Idle | ... 0 ,, ... | — | .. |
| Total... | 8¼ ,, | 100 | 12·1 |
| 2nd 100 feet took | 19¼ days... | 91 = | 5·2 |
| Idle | ... 2 ,, .. | 9 | ... |
| Total... | 21¼ ,, | 100 = | 4·7 |
| 3rd 100 feet took | 50½ days... | 85 | 1·9 |
| Idle | ... 11 ,, ... | 15 | ... |
| Total... | 61½ ,, ... | 100 | 1·6 |

| | | Per cent. | Rat per day. Ft. |
|---|---|---|---|
| 1st 100 feet took | 6 days ... | 100 | ... |
| Idle | ... 0 ,, ... | — | ... |
| Total | ... 6 ,, ... | 100 | 16·6 |
| 2nd 100 feet took | 15 days... | 79 = | 6·6 |
| Idle | ... 4 ,, ... | 21 | ... |
| Total | ... 19 ,, ... | 100 = | 5·3 |
| 3rd 100 feet took | 31 days... | 73·9 | 3·2 |
| Idle | ... 11 ,, ... | 26·1 | ... |
| Total | ... 42 ,, ... | 100·0 | 2·4 |

Of the 31 days' boring, 11½ were taken up in fishing up a broken pump, and lifting up pipes, and lowering them again.

SPEED OF BORING.—*Continued.*

| | | | |
|---|---|---|---|
| 300 feet took 78 days | ... 85·7 | 3·8 | |
| Idle 13 ,, | ... 12·9 | ... | |
| Total 91 ,, | ...100·0 | 3·2 | |
| The last 50 feet took 56 days | 78·8 | 0·9 | |
| Idle ... ... 15 ,, | 21·2 | ... | |
| Total ... 71 ,, | 100·0 | 0·7 | |
| 350 feet took 134 days | ... 82·7 | = 2·7 | |
| Idle ... 28 ,, | ... 17·3 | ... | |
| Total 162 ,, | 100·0 | = 2·1 | |
| 300 feet took 52 days | ... 77·6 | = 5·7 | |
| Idle ... 15 ,, | ... 22·4 | ... | |
| Total 67 ,, | ...100·0 | = 4·5 | |

The hole stands at this depth.

COMPARATIVE COST OF

HAND BORING.

| | Rup. | A. | P. | Rup. | A. | P. |
|---|---|---|---|---|---|---|
| 1st 100 feet took 8¼ days— | | | | R | A. | P. |
| 8¼ days at ... | 11 | 15 | 0 = | 98 | 7 | 9 |
| Cost per foot ... | 0 | 15 | 9·09 | | | |
| 2nd 100 feet took 21¼ days— | | | | | | |
| 19¼ at | 11 | 15 | 0 = | 229 | 12 | 9 |
| 2 days idle at | 0 | 7 | 0 = | 0 | 14 | 0 |
| | | | | 230 | 10 | 9 |
| Cost per foot = | | | | 2 | 4 | 10·89 |
| 200 feet cost | | | | 329 | 2 | 6 |
| Cost per foot | | | | 1 | 10 | 3·99 |
| 3rd 100 feet took 61½ days— | | | | | | |
| 50½ at | 11 | 15 | 0 = | 602 | 13 | 6 |
| 11 at | 0 | 7 | 0 = | 4 | 13 | 0 |
| | | | | 607 | 10 | 6 |
| Cost per foot... | | | | 6 | 0 | 5·46 |
| Cost of 300 feet | | | | 936 | 13 | 0 |
| Cost per foot.. | | | | 3 | 1 | 11·56 |
| 4th 50 feet took 71 days— | | | | | | |
| 56 at | 11 | 15 | 0 = | 668 | 8 | 0 |
| 15 at | 0 | 7 | 0 = | 6 | 9 | 0 |
| | | | | 675 | 1 | 0 |
| Cost per foot of 4th $\frac{50}{100}$ = | | | | 13 | 8 | 0·24 |
| Total cost of 350 feet ... = | | | | 1,611 | 14 | 0 |
| Total per foot | | | | 4 | 9 | 8·23 |

STEAM BORING.

| | Rup. | A. | P. | Rup. | A. | P. |
|---|---|---|---|---|---|---|
| 1st 100 feet took 6 days— | | | | R. | A. | P. |
| 6 days at ... | 7 | 10 | 9 = | 46 | 0 | 6 |
| Cost per foot ... | 0 | 7 | 4·38 | | | |
| 2nd 100 feet took 19 days— | | | | | | |
| 15 at | 7 | 10 | 9 = | 115 | 1 | 3 |
| 4 days' idle at | 0 | 7 | 0 = | 1 | 12 | 0 |
| | | | | 116 | 13 | 0 |
| Cost per feet = | | | | 1 | 2 | 8·21 |
| 200 feet cost | | | | 162 | 13 | 6 |
| Cost per foot | | | | 0 | 13 | 0·33 |
| 3rd 100 feet took 42 days— | | | | | | |
| 31 at | 7 | 10 | 9 = | 237 | 13 | 3 |
| 11 at | 0 | 7 | 0 = | 4 | 13 | 0 |
| | | | | 242 | 10 | 3 |
| Cost per foot ... | | | | 2 | 6 | 9·87 |
| Cost of 300 feet | | | | 405 | 7 | 6 |
| Cost per foot ... | | | | 1 | 5 | 7·4 |
| | | | | | 405 | 7 | 6 |

These figures prove conclusively that boreholes of 300 feet can be put down 26 per cent. quicker and 30 per cent. cheaper by steam than by hand, it taking 91 days by hand and 67 by steam, and costing 607 rupees by hand and 405 rupees by steam.

Beyond that depth steam must be cheaper by far, for the last 50 feet of the hand boring (that is of the 350 feet total depth) cost 13 rupees, 8 annas, 0·24 pies per foot, or 675 rupees, or more than the cost of the first 300 feet. It is only at greater depths that steam boring becomes cheap to a very great extent, and as the steam borehole was to go down 450 feet, the saving at that depth over hand-boring would have been 200 or 300 per cent. at least. Then again, it must be taken into account that the steam boring under notice was the first of its kind in India, and the men had of course no experience in working the machinery, and the speed and cost would have been greater and less respectively, if boring-pipes of sufficient length had been on the spot. The hole had to be piped its entire depth, nearly, by tubes which did not reach 150 feet from the surface. The hole was commenced 8 inches diameter, and had three different sizes of tubing, two sizes not reaching the surface.

Considering that the idea of using boring rods with a Canadian rig is a novel one, and taking into account the difficulties which always accompany a new departure, the depth also being small, the saving effected amply justifies its use at depths of 300 feet and upwards.

A section of the borehole is not given, as it is only of local interest.

## THE UNDERGROUND FIRE.

Although the Warora coal contains no fire-damp, it is subject, as before-mentioned, to spontaneous combustion, and at Warora Colliery, in the beginning of 1882, in No. 2 Seam, an outbreak of fire occurred on the north side of No. 2 Pit, in a part where the long-wall system of working had been attempted, but had resulted in failure. From that time to this, all efforts to subdue the fire have failed, and the area affected in the No. 2 Seam has increased to an extent of about 27 acres of coal standing in pillars, worked to the extent of 50 per cent. (about), and containing 400,000 tons of coal. Allowing the workable thickness to be 10 feet, deducting half as the quantity already worked, and then allowing 50 per cent. for waste, there will not be far short of 100,000 tons of coal which has been lost.

This fire has, unfortunately, caused the death of a mining engineer, and often seriously imperilled the fortunes of the colliery. Its origin can only be traced to the packing of the attempted longwall goaves with small coal (which was at the time unsaleable), and to a want of ventilation. Before actual fire appeared, it had often been found that accumulations of small coal had been heating, but this was combated by driving through the mass and cooling it with currents of air. At the time of the fire there was no proper system of ventilation.

The first serious outbreak of fire occurred at the end of January, 1882, in the goaf of some longwall, which had been tried to the north of No. 2 Pit. Heating of this goaf had been experienced as early as 1877, when, thanks to the energetic measures taken by Mr. Ness, the then manager, a serious outbreak of fire was prevented. The heating was evidently due to the spontaneous combustion of the small coal with which the goaf had been packed; as in previous years, there having been so little demand for small coal, it was not raised to the surface, but stowed underground. No doubt, to a very great extent, the want of a proper system of ventilation caused the heating of the coal. At that time there was only a furnace at No. 2 Pit to create the ventilation, but there was a want of coursing for leading the air in channels or galleries in and out of the mine. The fire was kept down by walling it off.

In April, 1882, a second fire occurred at a spot 110 feet north-west of No. 2 Pit. The fire occurred in slack coal, and was also walled off. In the end of April a third fire occurred near where No. 1 fire broke out. This again was kept under by walls. In the meantime, Nos. 1 and 3 fires kept increasing, until in June the situation became critical. On the 30th of June a final outburst occurred, and Mr. Macdonald, the Mining Engineer of the Colliery, while personally endeavouring to see all the men safely out of the pit succumbed, as he was carrying a native out of reach of the noxious gases. The native was also found dead.

It had previously been decided to flood the pit, and, accordingly, in No. 1 Pit, the pumps were stopped and the water allowed to rise for 18 days, when, on the 20th, it had risen to 21 feet 7 inches in No. 1 Pit, and 15 feet 1 inch in No. 2 Pit the pumps commenced again to pump. The then Mining Engineer in charge decided that the pits should be drained again, and, on August 10th, the water was pumped down in No. 1 Pit.

Although flooding the mine was of little use when the area

to be flooded was to the rise, and no holing made in the rise for the pent-up air to escape, yet it was a pity that the mine was not longer kept flooded, say for two or three years, and endeavours made from No. 4 Pit to give the air in the rise a holing to escape, and thus effectually allow the water to reach the different spots where the fire was burning.

It can hardly be said that this flooding was a flooding at all from the maximum height of water in the pit, not taking into account pressure for pent-up air, which would only make the level of water flow to a distance of 520 feet from No. 1 Pit to the rise, allowing a rise of $1\frac{1}{2}$ inches to the yard, and then it would not be roof height there, but only at a distance of 200 feet would the water have reached the roof. This proves that the fire which was said to be burning was not reached.

As the water was pumped down, stoppings were built all round the fire area of any material handy, and these temporary stoppings were subsequently all replaced by brick in lime and basalt wall stoppings.

Since then this fire has slowly been encroaching, and its boundary now is threateningly near Nos. 1 and 2 Pits.

The chief means used in checking the fire has been by cutting off the air, formerly by mud and stones, or bricks, and now with brick in lime stoppings, and basalt stone stoppings, the latter preferable on account of the Warora brick being so poor in quality. Carbonic acid was proposed, but not tried. Flooding was resorted to for three months, but, for reasons already given, was ineffectual. Recently it was proposed to flood the affected part of the mine thoroughly, and keep it flooded some years, but change of management intervened, and the scheme was abandoned. Stoppings to seal off the air have not proved thoroughly effectual, for as No. 2 Seam was worked in the bottom, leaving part of the seam as a roof, the stoppings were only built up to this coal roof, over which the fire always makes its appearance. The stone roof above the coal is so bad, that attempts to build stoppings through the coal to this roof have not proved successful; but as these attempts were made with Warora brick, success was hardly to be expected. Basalt stone would prove an effectual wall if built through the roof coal; but again, the bounding line of the fire being extensive, the expense would be great.

In 1884, the writer succeeded in winning a large space from the fire by entering the fire area some distance from the active part, and by bratticing, and with stoppings of brick, success was

attained. But on account of the pillars having been wrought too small, some not more than 20 feet square, and on account of the great height of top coal taken down, the very poor roof of the seam (which consists of a black mottled shale, 3 feet 2 inches thick and seggar clay above), frequently fell in, and ultimately the area recovered had to be abandoned. In fact, this area has been ruined by the small pillars which were unable to support the roof, (the cover varies from 180 feet in the dip to 150 feet in the rise), and should it ever be regained, not more than 50 per cent. of the coal now standing in pillars could be got. In opening out this area in the seam, the Fleuss dress was tried, but given up owing to the heat of the workings. Three Fleuss dresses were got with the necessary lamps, but enough confidence in the apparatus could not be mustered to attempt any exploring. The intake air was 80 degs., which soon after entering the area rose to 104 degs. This was in the air-ways, but when attempts were made to enter the fire area with the Fleuss dresses without air, the heat was intolerable.

In 1883, No. 3 Seam was opened out from No. 2 Pit, and worked under the fire area of No. 2 Seam, although there are only 5 feet of intervening shaly strata, and 5 feet of roof coal in No. 3 Seam. The seam was opened out on the bord and pillar system, with 12 feet bords, 7 feet headways, and 45 feet square pillars, thus working only 33 per cent. of the area in the lower (8 feet thick) portion of the seam. No great difficulty was experienced in doing this, except in places where more than 8 feet of the thickness of coal had been won, leaving then too little roof coal to support the intervening shaly strata, which weather rapidly on exposure to the air, and caused falls, which were likely to extend into No. 2 Seam fire area. These falls, when they occurred, were always immediately walled in, and, as these walls are warm, and hot water flows from them, there is no doubt that they connect No. 3 Seam with the fire. As long as there was any coal to work in No. 3 Seam in the whole (to work the coal in the broken with a fire only 10 to 12 feet above would be impossible), the expense incurred in checking and keeping back the fire above was allowable, but now that all the coal in No. 3 Seam that can be won has been got, it would seem that the best policy would be to abandon both seams, together with Pits Nos. 1 and 2 lying in the affected area, and commence a new winning in another portion of the coal-field.

In March, 1885, another fire broke out in some broken workings in No. 2 Seam, south-east of No. 4 Pit. The affected area of about 4 acres was walled in with 34 brick stoppings, and has given no trouble since. The walling-in was completed before any actual fire was seen, but from the gases which came off (CO and $CO_2$) there was no doubt that if in the interior a fire was not in existence, a serious heating of goaf was taking place, and the gases emitted were obnoxious enough to justify the precautions taken. This fire was occasioned by the pillars being so small that, while working the broken, many small pillars were buried up in the goaf, which eventually fired.

In August, 1887, another fire occurred in No. 2 Seam in the broken, being worked south-west of No. 4 Pit. This broken had been worked with care, and little coal was lost, but the area of the goaf was getting extensive, and from the number of years it had been laid down (about 4 years), it appears that spontaneous combustion must have occurred in the top coal left in the broken, and, as in the other case, showed itself only by emitting carbonic oxide and carbon anhydride. 23 stoppings were as soon as possible built, and since then the area has given no trouble.

Mention must here be made that the gas given off by the active fire area, that is, in those parts where actual fire exists, is carbonic acid, while in those parts where a heating of the mass is only observed, carbonic oxide makes its appearance. In 1884, the writer found some carbonic oxide coming off in the area, which was for a time recovered, but the quantity was so small, and was found only once, that its existence was looked upon as problematical by the Government. In 1886, however, when the south-east broken began seriously to heat, the presence of this poisonous gas was undoubtedly proved by men being knocked down in it with their lamps burning, and on one occasion it was lighted in the roof in the presence of three officials and many men, when it burned with its characteristic light-blue flame.

It may now be conclusively stated that at the present time three areas of No. 2 Seam are under the effects of spontaneous combustion, the first and largest area being under the active effects, and the two others under subdued effects.

| | Acres. |
|---|---|
| The area of the largest, active, and most dangerous portion is ... ... ... ... | 30 |
| The south-east hot area ... ... ... ... | 4 |
| The south-west hot area ... ... ... ... | 8 |
| Total ... ... ... ... | 42 |

In the first area there remain over 100,000 tons of coal, which could be worked, allowing amply for waste. In the other areas there remains no coal to be recovered, as they are laid down in goaf.

It will thus be seen that the three fires mentioned have occasioned a loss of at least 100,000 tons of available coal in No. 2 Seam.

In the No. 3 Seam below, these fires have caused a much greater loss, for no broken work can be attempted, and as only 33 per cent. has been worked in the whole, there remain, taking the workable thickness of coal at 10 feet, 711,000 tons of coal, of which, if no fire had existed, 474,000 tons of coal could have been worked, and of which two-thirds will now have to be wasted in getting as much coal as possible by splitting the pillars, leaving even then a doubtful quantity of 150,000 tons of coal to be won, or a loss of nearly 325,000 tons of coal in No. 3 Seam, and, as before stated, in No. 2 Seam, 100,000—a total loss of 425,000 tons, or three years' output at the present rate of extraction, viz., 130,000 tons per annum.

Besides this loss of coal an annual expenditure of from £500 to £1,000 has been incurred since the outbreak of the fire in 1882 in keeping the fires within bounds.

From the foregoing account of the underground fire at Warora, it will be seen that Warora coal, after it has been wrought, should not be left in the workings. On two occasions the writer has come across heating masses of small coal; one instance only in July, 1887, when in a gallery, driven some distance ahead of any air holing, some small coal lying quite dry was heating and giving off visible, and fire-smelling fumes which did not put out a naked light. The coal was so hot that it could hardly be held in the hand.

Also the workings should be thoroughly and liberally ventilated. And, as it is plain that danger exists, when working the coal off in the broken, the workings should be arranged in panels surrounded by substantial barriers, the area of these panels to be regulated, so that before a fire has had time to "grow" the panel will have been worked off. From the experience gained at Warora when the south-west broken No. 4 Pit showed signs of fire, and where 4 to 8 acres had been laid down in the broken, the panels should be made to contain an area of coal no larger than say 4½ acres.

The coal, owing to its holding much water, crumbles, like many lignites, gradually by exposure to the air for some time. Owing to this weathering action the coal loses in value, the large coal swells, opens out, assumes the appearance of charcoal, and crumbles into small pieces. The small coal soon resembles dust. This deteriorating effect of stacking the coal is well known, and the Great Indian Peninsular Railway Company, who are the largest customers, will take only the coal freshly mined, and not from any heaps of coal that may have been stacked on the surface.

It is well known that all coals, more or less, absorb oxygen, or, in other words, oxidise. The process of oxidation will proceed at a normal temperature, until the complete oxidation of the easily oxidised constituents has taken place. Carbon dioxide may be driven off, and at higher temperatures, both carbon dioxide and water are driven off. When this absorption takes place slowly, the heat produced will be disseminated, and no appreciable rise of temperature will result, the oxygen and hydrogen remaining condensed in the pores. Should the absorption take place rapidly, then the hydrogen and oxygen gases are expelled, and fresh oxygen is absorbed, producing more heat. With this increase of temperature, an energetic chemical action sets in between the oxygen and the combustible material of the coal, the result of which is finally spontaneous combustion. The larger surface of coal dust and small coal, presented by the particles, causes absorption to take place more rapidly, and this, together with the fact that in heaps of small coal and dust, a difficulty exists of furnishing the heaps with sufficient air to carry away the heat, is the reason why coal dust and small coal are more readily the prey of spontaneous combustion. The crumbling of the coal may be due to the absorption of oxygen and the resulting compression of the carbon dioxide, which must exert a pressure on the walls of the pores. Or the cementing element may be disturbed by the chemical reactions. But of great importance in connection with the crumbling action is that the hygroscopic moisture evaporates after a time, leaving the fine cracks and pores free for the penetration of the oxygen of the air, thus exposing a larger surface for its action. And as the escape of hygroscopic water cannot take place without the production of mechanical alterations, the coal cracks and crumbles when it is stored or stacked. Lignite loses little in calorific power by crumbling, but considerably in commercial value. As to the existence

of pyrites in aiding spontaneous combustion, Fayre, an eminent French authority, has, after making careful experiments, drawn the following conclusions:—"(1.) The first and greatest cause of spontaneous combustion is the absorption of oxygen by the coal. (2.) The most favourable conditions for the self-heating of coal are a mixture of pieces and dust, an elevated temperature, a large seam of coal, and a certain volume of air. (3.) Large pieces, low temperature, small volume, and the complete absence of air, or good ventilation, act in opposition to self-heating. (4.) In general, pyrites plays only an unimportant, mostly insignificant, part in spontaneous combustion. (5.) Mechanical forces, or the heat produced thereby, cannot be assigned as the usual causes of the burning of coal mines. The pyrites can only produce an appreciable effect in the increase of temperature when present in considerable quantities, and then only in presence of moisture and air; in the dry state this must be regarded as perfectly passive, and may even be detrimental to the warming."

In order to save stacked lignite from spontaneous combustion and crumbling, it has been the practice in Germany and Austria to stack the lignite over spent steam from any of the engines working at the colliery. This surrounding of the coal with vapour from the steam displaces the air with its oxygen, and thus prevents the escape of the hygroscopic moisture of the coal, thereby checking and annulling chemical action, and saving the coal from spontaneous combustion and deterioration by crumbling. The writer recommended the Government of India to try this plan of stacking with Warora coal to prevent its firing and deteriorating, and a sum was consequently granted to try the experiment, but somehow or other it was never carried out.

## THE COLLIERY ABOVE GROUND.

The colliery, in its present form, consists of 6 pits, known by consecutive numbers in the order in which they were sunk. No. 1 Pit is the pumping shaft, and now a downcast. No. 2 Pit, a winding shaft, and also now a downcast but which was formerly the furnace upcast. No. 3 Pit, a pumping and downcast shaft. No. 4 Pit, a winding and now downcast, though formerly it was a furnace upcast with a brattice and a downcast combined. No. 5 Pit, a winding and downcast and No. 6 Pit, the fan upcast, 15 feet diameter in

the clear sunk in the western boundary, and to the rise of the others, and 100 feet deep. This pit and the sinking of the lower part of No. 5 Pit were completed within the last five years.

No. 1 Pit is 190 feet deep; No. 2, 220 feet; No. 3, 250 feet; No. 4, 190 feet; No. 5, 175 feet; and No. 6, 100 feet.

All the pits are supplied with sidings, and connected with the Wardha Coal State Railway by a branch line. In appearance, the colliery, with heapstead, pulley legs, and screens, bears an unmistakeable likeness to collieries in England, and but for the coloured labour of both sexes, in the scantiest of clothing, no difference would be noticed between a colliery in England and this one. In fact, Warora was once the only pronounced English type of a colliery in India, for it was here that first screens and the regular plant of pulley legs and heapsteads were introduced, the usual collieries of India then consisting of a number of shallow pits close together with no screens, the coal being wound by gins and crabs set in motion by numbers of native women, men, and children, and the coal hand-picked. This state of things exists still to a great extent in the Raniganj Coalfield, in Bengal, but the larger collieries there, managed by Europeans, are gradually concentrating their outputs to single pits and winding with machinery.

The workshops of the Wardha Coal State Railway adjoins and forms part of the surface establishment of the colliery. These workshops employ now a little over one hundred men, but are capable of affording employment for twice that number. The shops are elaborately, even lavishly, fitted up with engineering tools in the machine-fitting and erecting shops, foundry, blacksmiths' and carpenters' sheds, and a very fine store building, with powder and explosive magazines, completes the view of the establishment.

There is nothing, as regards the surface colliery plant, which calls for any attention. The winding engine at one pit is of the double high-pressure direct-acting type, the other two pits have semi-portable winding engines, and those in duplicate at No. 4 Pit.

The pulley legs are of wood and of moderate height; the pulley centres being 33 feet from flat sheets, and the screens short and of an old type. The pit tops are provided with gates moved by the cages. The cages run in rope guides at No. 2 Pit, wood guides at No. 4 Pit, and iron rail guides at No. 5 Pit. The pits themselves are very small: No. 1 Pit being 9 feet diameter; No. 2 Pit, 10 to 11 feet diameter; No. 3 Pit, 9 feet diameter; No. 4 Pit is rectangular, 4 feet by 6 feet; No. 5 Pit, rectangular, 5 feet by 10 feet; and No.

6 Pit, the latest, the author would not have less than 15 feet diameter, and is round.

The cages are all single decked and hold one tub. The tubs are of iron on wooden frames, the body is 2 feet deep, 3 feet wide, and 4 feet long, and stands 37 inches above the rails. The wheels are of the Hadfield pattern steel, 10 inches diameter on the tread. Their gauge is 22 inches. These tubs hold ½ ton of coals, and their tare is about 4½ cwts. The winding ropes used are of steel 2¼ inches circumference—Lang's patent. The ropes were always tested by the author after finding that a rope supplied by a native firm in Calcutta did not reach its alleged breaking weight by 50 per cent. The ropes now used have a breaking weight always tested of over 23 tons, the working load is 30 cwts., giving a safety margin of 15. This factor of safety may seem to Mining Engineers in this country very high, but the writer thinks that, when taking into account the employment of natives as enginemen, with a supervision composed largely of natives, and the severe climate, the smallness of the pulleys, bad lead off the drum, and other mining considerations, it is better to err on the safe side. The ropes are properly greased once a week, and examined daily. The ropes wear easily two years, and then show only about two or three broken wires. The hosing or socketing is done by the native blacksmiths, who, of all native trained artisans, are the cleverest and most reliable at their work. The winding enginemen work 6 hours per day, all other aboveground colliery employees working 8 hours, and the skill with which they handle their engines is surprising. With the direct winding engine at No. 2 Pit, with an 8 feet diameter drum; depth 230 feet from flat-sheet to flat-sheet; engine, double-cylindered 15 inches diameter by 2 feet stroke with 40 pounds steam pressure; the speed of an ordinary skilled native in winding is at the average rate of 10½ feet per second for the whole winding. With the 16 horse-power geared Robey engine at No. 4 Pit, geared 6 to 1, the speed averages 7¼ feet per second. During the five years of the writer's management of the colliery no case of overwinding has occurred. No safety hooks are used, for there is hardly 20 feet of space between cage top at bank and pulleys.

The screen sidings are so arranged that the wagons gravitate to a marshalling siding, where the colliery locomotive takes them away. Only two sorts of coal are vended, large coming over a screen with bars spaced 1 inch apart, and small coal passing

through the screens. The coal is cleaned to a small extent, after the trucks are loaded, by the screeners and women, who superficially pick out of the truck stones which might catch the eye of the Great Indian Railway Company's Coal Inspector. No women are employed underground, which seriously raises the cost per ton of getting the coal, this cost being high compared with other collieries in the Raniganj district. At all other collieries in India, save Umaria, which, like Warora, is a State colliery, and under the same management, women are freely employed underground; still, the writer thinks the Government are perhaps right in not allowing female labour below ground; on the surface they assist in hand-shunting the wagons to and from the screens, but are not allowed on the heapsteads or screens.

Before taking leave of the surface, a word as regards the pumping arrangements will not be out of place. The total feeders of the colliery do not certainly exceed 800 gallons a minute, and would more likely be 600 if properly measured. To pump this quantity of water there are six pumping engines which could be replaced with considerable economy by one engine. It may well be imagined when it is added that three of the engines are old, rickety ones with pumping sets leaking like rainy skies in the monsoon season, what the cost in repairs and maintenance must be. However, the cost of pumping will be detailed at length, when the cost of working is gone into.

At No. 1 Pit a small geared, horizontal engine, single cylinder, 15 inches diameter, works two lifting sets by means of bell cranks, two 12-inch sets, with a 5 feet stroke. The pump trees are of cast-iron, 14 inches diameter, and 12 feet long, and are hung by ropes. It was in fact the old sinking set. Another single cylinder engine at the same pit, 15-inch cylinder, works also two sets of lifting pumps, one 12 inches and one 13 inches diameter, by a 6 feet stroke. Here, also, the pump trees are of wrought-iron, but are fastened to buntons.

Here, at this pit, are four sets of bucket leathers to grathe almost constantly, and although the depth is only 200 feet, yet quite a staff of native grathers have to be employed. These pumps only pump water from the No. 2 seam. Allowing these engines five double strokes a minute, they could pump with ease 400 gallons a minute if in good repair, but their capability is not more than 200 gallons a minute, and as they consume such large quantities of steam, being geared and high pressure, non-expansive, and non-condensing,

there is not sufficient steam to keep the two engines constantly going together at a time.

At No. 3 Pit there is another old horizontal pumping engine cylinder 20 inches by four feet stroke, geared, and working by bell cranks, two lifting sets, 13 inches diameter by a 5 feet stroke, pumping to a height of nearly 250 feet. The rising main pump trees are made also of wrought-iron. This engine, at five strokes a minute, is capable of pumping 200 gallons a minute, or should be if in thorough repair. At this pit, besides, are two Cornish beam engines, of 35 horse-power each, with cylinders 36 inches diameter. Each of these engines works a single lifting set of 15 inches diameter by an 8 feet stroke, and these engines should pump, at 8 strokes a minute, 700 gallons a minute comfortably. One pump has a wooden spear, and the other has a galvanised iron rope spear, which is, however, now being replaced by wooden spears. The putting in of a rope spear was a mistake, it has given infinite trouble, and the cost alone of the broken ropes would nearly have been sufficient to have fitted the pumps with wooden spears at once. The rope is 6½ inches in diameter, and weighs 8 cwts., being 216 feet long. The total weight of rope, weights, foot-rod, and bucket is 3 tons 2 cwts. The great trouble experienced was in the down stroke, when the rope being too light, balance weights had to be appended in the set near the bucket connection. These weights which were of lead and antimony weighing 1½ tons, blocked up the water passage, damaging also the pump trees, and when these weights were taken out during the course of repairs, they were a source of annoyance in having to be carefully watched, for the natives find them useful for stealing and selling the lead in the bazaar, where it finds a ready market. At this pit there are six boilers, all Cornish, but enough steam cannot be maintained to keep all these engines going together. Only two can be kept going at once. Finally, at No. 5 Pit, there is a non-expansive and non-condensing pumping engine of the direct-acting special type placed underground. The steam cylinder is 16 inches diameter, and the pump cylinder 12 inches, with a two feet stroke, and pumps in one lift of 180 feet to the surface. This pump, owing to want of steam, can only be kept going at 12 double strokes a minute, equal to a quantity of 170 gallons a minute, which is a little more than half the feeder; the rest finds its way to No. 3 Pit. This pump is supplied with steam from an old locomotive boiler, at a pressure of 90 to 100 lbs. per square inch.

Summarising the various engines, the work done is as follows:—

| No. | Engines. | Sets. | Strokes a minute. | Number of Boilers. | Capable of pumping if in thorough repair, and with plenty of steam. | What practically is pumped per minute. | At Pits. |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 2-12 in. Sets. 5 ft. Stroke. | 5 Double Strokes. | 5 Boilers. | About 200 galls. a min. | 125 | No. 1 |
| 2 | 1 | 1-12 in. Set. 1-13 in. Set. × 6 ft. Stroke. | 5 Double Strokes. | | About 250 galls. a min. | 150 | 1 |
| 3 | 1 | 2-13 in. Sets. 5 ft. Stroke. | 6 Double Strokes. | 6 Boilers. | About 250 galls. a min. | 175 | 3 |
| 4 & 5 | 2 | 2-14 in. Sets. × 8 ft. Stroke. | 8 Double Strokes. | | About 700 galls. a min. | 700 | 3 |
| 6 | 1 | 1-12 in. Set. Plunger × 2 ft. | 12Double Strokes. | 1 Loco. Boiler. | About 300 galls. a min. | 170 | 5 |
| | | | | | 1,700 | 1,320 | |

If all the engines could be kept going in their present state, 1,320 gallons a minute could be pumped, and if they were in better repair, and a little more steam provided, 1,700 gallons could be pumped, but as it is, only one of the first two engines can be kept going at once,

| | Gals. a minute. |
|---|---|
| which means, say on an average ... ... | 140 |
| Engines No. 3 and 4, 3 and 5, or 4 and 5 ... | 580 |
| No. 6 ... ... ... ... ... ... | 170 |
| | 890 |

which represents the present available pumping power of the colliery.

Apart from all this, it seems, on the face of it, absurd that six pumping engines, with all their attendant expenses, such as enginemen, oil boys, cleaners, repairs, and supervision, should be employed, when one large engine would do all the work, or, at most two, one being held in reserve. Every day the feeders are increasing, owing to the opening out of the coalfield to the south, and it will become a matter of importance, if the colliery is to keep up its present output and position, to consider in what way the present cumbruous and expensive pumping plant can be replaced by good and economical machinery.

The colliery possesses 17 boilers.

| | At Work. | | Idle. | | Pressed tolbs. per sq. in. |
|---|---|---|---|---|---|
| 2 Cornish and 3 Lancashire at No. 1 Pit | 4 | ... | 1 | ... | 40 to 45 |
| 6 Cornish at No. 3 Pit ... ... ... | 5 | ... | 1 | ... | do. |
| Locomotive type at No. 4 Pit ... .. | 1 | ... | 1 | ... | 100 |
| ,, ,, at No. 5 Pit ... ... | 2 | ... | 0 | ... | 100 |
| ,, ,, at No. 6 Pit ... ... | 2 | ... | 0 | ... | 80 |
| | 14 | ... | 3—total 17. | | |

all in good repair.

Before taking leave of the surface plant, it would be well to say something of the coal wagons, which are very superior to the ones used in England, especially as regards the chauldron wagon, whose ugly and uncouth form still exists in the North of England.

These wagons are 22½ feet long from buffer to buffer, and 18 feet long inside of the body. The wheel centres are 11 feet apart. The wheels are 3½ feet diameter in the tread, and the buffers are steel spring buffers. The gauge is 5½ feet. The body inside measures 18 feet long by 8 feet 8¼ inches wide, and 2 feet 11 inches deep=456 cubic feet, and carries 10 tons, or 1 ton per 45½ cubic feet about. The top of the wagon stands 7 feet above rails, and centre of buffer 3 feet 7¾ inches above rails; its extreme breadth is 8 feet 8½ inches. These wagons are built entirely of iron and steel, and the first ones had doors on one side to facilitate unloading, but the latter ones had no doors, for labour is so cheap that the question of loading or unloading is too trivial to consider, as regards cost. As a matter of fact, 1 anna (1 penny) per ton is paid for loading or unloading coal into these trucks. Brakes are fitted to the truck. The late ones were built by the Ashbury Railway Carriage Builders, Manchester.

200 such wagons cost, at Warora, 337,463 rupees, or 1,687 rupees a piece, or £112½ at present exchange rate.

## VENTILATION.

The great thickness of the seams, the shallow depth, the large number of downcast pits—5 in number—and the favourable position of the upcast to the rise of all the workings, with its large diameter, and free from all buntons and encumbrances, all tend to increase the efficiency of the ventilation of the colliery by a fan. When the writer first took over the management of the colliery, his opinion was asked as to what ventilation he would suggest, and he unhesitatingly recommended the Waddell Fan as being the cheapest, and, in his opinion, the most efficient of the fans then in existence; and he is glad to find that even now, five years later, the Waddell Fan is still looked upon as a very successful one. The

Fan was erected in 1887, and commenced working in February of that year, although ordered in India in 1884. This shows how slowly papers travel in and out of red tape under Government fingers. The Fan which is 30 feet diameter, the engine, a single one, having a 20-inch cylinder by a 3-feet stroke, exhausts 160,000 cubic feet per minute, with a $\frac{7}{10}$-inch water gauge, at a speed of 45 revolutions per minute, supplied with steam from two 25 horse-power locomotive boilers.

Before the Fan was started, the ventilation was carried on by two furnaces, aided by the exhaust steam and heat from an underground engine and boiler; and at its best, that is in the cold seam, 45,000 cubic feet could only be obtained. In the hot weather, however, with the sun shining on the upcast pits and the temperature in the sun at 150 degs. Fah., the ventilation almost came to a stand-still owing to the little difference of temperature between pit bottom and top. Still the temperature underground was not so great, not more than 90 degs. Fah., but the atmosphere being saturated with moisture, made work to any European impossible. Then again the carbonic acid being constantly given off by the large areas of the exposed coal which were oxidising, and the presence of a large fire underground, made the air very unhealthy, and seriously affected the healths of all concerned even down to the natives. This is all changed now; in the hot season it is more pleasant to be below than above ground, the temperature never exceeds 84 degs. in the returns and is as low as 57 degs. Fah. in the intake in winter, and going up to 88 and 90 degs. in the hot season. Strange to say, the returns remain at the same temperature winter and summer, but the intakes in winter are much cooler than in summer, being affected by the surface temperature, and the intakes get warmer in winter as they proceed to the upcast, and colder in summer. The air in the dry seasons, viz., winter and hot seasons, enters the mine almost dry, but rapidly absorbs moisture and is very soon saturated long before it reaches the workings. The ventilation is now arranged in a style that would do honour to a gassy district in England, being replete with 12 splits, air-crossings, regulators, doors, etc. On an average there is per man 300 cubic feet of air per minute, and in no district is it allowed to fall under 110 cubic feet per man per minute. Great was the astonishment of the natives when the Fan was set to work, hundreds coming to see it from all parts of the surrounding district. The Fan engine is supplied with steam from

two locomotive type of boilers working under a pressure of 80 lbs. per square inch. These boilers are very unsuitable for colliery work where the water contains much sediment, as at Warora. Here they had to be cleaned out once a week, and then only could the more easily accessible part be got at, and consequently the Fan engine was always at a standstill on Sundays.

Great care must be taken in keeping all the districts sufficiently cool, to guard against spontaneous combustion, which is feared as much at Warora as fire-damp is in England; and the writer had thermometers erected in all the intakes and return air-ways, which were read and recorded twice a day by a native overman or fireman. However, during a wave of economy, which was and is still sweeping over the Indian Government, this native thermometer reader was dispensed with, although only earning 25 rupees per month, or £1 13s. 4d. Plenty of ventilation up to a certain temperature is the great preventive for underground fires, above that given temperature, which varies from 140 degs. to 212 degs., the less air the better. Experience has proved, at Warora, that with the first signs of carbonic oxide there is time to wall off an extensive area before actual fire shows itself. Small coal and shale should not be allowed to lie in the mine. Frequently have heaps of coal been found dangerously heating in places a long way ahead of the ventilation current—say, 120 feet from the nearest air current. Galleries, when not holed, are not ventilated by a brattice, but the air currents are kept up to the innermost holings, and all places beyond are ventilated by diffusion. The heat in these places is not excessive, provided they are not more than 70 feet ahead of the air.

| | | |
|---|---|---|
| The Waddell Fan, with engine and gear, cost ... | 8,665 | rupees. |
| Including carriage of same, fitting of same, and boilers | 1,500 | „ |
| 225-h.p. locomotive multibular boilers and carriage | 17,000 | „ |
| Steam pipes ... ... ... ... ... | 500 | „ |
| Excavating for foundation, building in foundation, and erecting 12,153 cubic feet of brickwork masonry, and 254 of ashlar masonry, and fitting engine-house completely ... ... ... | 8,479 | „ |
| Roofing ... ... ... ... ... ... | 1,516 | „ |
| Water supply ... ... ... ... ... | 1,109 | „ |
| Unforeseen expenses . . ... ... ... | 1,163 | „ |
| Total ... ... ... ... | 39,932 | „ |

Equal to £2,662 at present rate of exchange—1s. 4d. per rupee.

The two boilers will hardly give enough steam if more air is needed; besides, they are both under steam, with no spare one.

The fan boilers consume nearly 150 tons of coal per month.

## UNDERGROUND WORK.

There is no Mines Regulation Act in India, but collieries are under the Indian Factories Act, which provides for the fencing off of all machinery, but further than that mine owners and mining engineers are unmolested by law. In 1883, unwritten rules and regulations governed the officials and workmen, but later the writer was allowed to make and draw up a set of rules observing, as closely as local circumstances permitted, the Mines Act of 1872. These rules are printed in English, and those parts affecting the different officials and workmen are translated and printed in the local dialects for the guidance of those few natives who can read. In 1888, these rules were revised, and perhaps they will ultimately guide those who draft an Indian Mines Regulation Act when the Indian Government thinks fit to move in the matter. Before proceeding to the manner of working the coal, it must be pointed out that all the coal is got by contract from the hewing, tramming, to part of the raising, onsetting, banking, screening and loading into trucks. For this purpose three to four native contractors are employed, who provide all the labour and oil, but who are provided with all tools, gunpowder, shots, and shot firers. The Government look after the underground management, and provide an efficient staff of native and European subordinates to see that the rules as to safety and economy are duly carried out. Lately it has been under the consideration of the Government to hand over the getting of the coal to one large native contractor, who will, for an increased rate, have to provide even tools and shots, and pay for all the winding expenses and all off-hand labour. This will make matters very easy as regards the management, for all the trouble in connection with the supervision of stores and tools will vanish. A contractor has now, the writer believes, been found, and success is looked forward to from the fact that the small contractors are men with no capital, who have to borrow money at an exorbitant interest from the native money-lenders, and who, therefore, have to make a very high profit to pay the interest on the borrowed capital and recoup themselves for their work. But, as the rates are rather too low for a great

profit, these contractors are in a chronic state of bankruptcy, and the work is hindered in consequence, hence it is believed a man with his own capital will be able to make a very handsome profit out of the contracts. There is no doubt, however, that if a private company managed the colliery, it would be better worked direct by the owners, and the contractor's profit thereby included in the total profits, but under Government management all those interested thus avoid responsibility, and therewith avoid as much work as possible. A scheme was submitted by the writer for working one pit direct without a contractor as a trial, but owing to the little authority given him over the office establishment it was never carried out. The rates given to the contractors in 1888 were:—

| | Indian Currency. R. A. | | Equal to English Currency. s. d. |
|---|---|---|---|
| The Large Coal wrought in the whole, screened and delivered into trucks at the marshalling sidings, at per ton ... | 1 4 | ... | 1 8 |
| Small Coal do. ... ... | 0 12 | ... | 1 0 |
| Large Coal, wrought in the broken mine, do. ... ... | 0 13 | ... | 1 1 |
| Small Coal do. ... ... | 0 8 | ... | 0 8 |
| The rates will be altered to Large Coal, wrought in the whole ... | 1 8 | ... | 2 0 |
| Small Coal do. do. ... | 0 13 | ... | 1 1 |
| Broken Mine, Large Coal ... | 1 1 | ... | 1 5 |
| Do. do. Small do. ... | 0 8 | ... | 0 8 |

Provided the contractor finds all off-hand labour, tools, gunpowder, winding establishment, onsetting, banking, screening, and getting the coal.

The rupee is taken at one shilling and fourpence, which is the current rate for all practical purposes.

The contractor has to sign a very long agreement, in which the clauses are very severe and a very one-sided affair, all the penalties being on his side and the benefits on the other. But the wily native contractor does not care, for should he lose money he appeals to the higher authority, and lays a number of complaints at the door of the management; nor does he forget to add in heart-broken language that he looks upon the Government as his father, bringing in his ignorance and the great confidence he has in the Indian Government as a plea for allowing his claims. And

he invariably succeeds, for he keeps on bothering so persistently, that to get peace one is obliged to allow him something for his claim. One cannot be too careful in dealing with a native who is well versed in the mysteries of Government routine; he is as wide awake to the money making part of the business as the managing official, and should he lose money he brings up and magnifies the smallest chance he has in upsetting the clauses of the agreement, and, finally, when all things fail he falls back upon his poverty and ignorance. The Government is benevolence itself when dealing with the natives abstractedly, and Anglo-Indians wish the same could be said with regard to the European officials, who suffer much from the depreciation of the silver currency. It may be of interest to add some of the more important clauses of the agreement—

"The contractor is to remove all stone, shale, and dirt partings, in which case dirt shall be synonymous with stone . . . . drive through all faults where the up or down-throw shall not exceed 6 feet, measured vertically; drift to be not less than 10 feet wide by 6 feet high . . . . the proportion of small coal to large shall not exceed 20 per cent. of the whole output of coal. Provided always that if the amount of small coal raised shall exceed 20 per cent. . . . . then the payments to be made . . . . shall be reduced to one anna per ton for every unit by which the amount of small coal raised shall be in excess of 20 per cent. of the output.

That the contractor will advance all winning places 15 feet a week on an average.

The contractor to drive all narrow and wide places (*i.e.*, places varying from 6 to 12 feet wide), other than winning places, at the rate of 9 feet per week on an average, and should he fail to do this, he agrees to pay a fine of two annas a ton short of the calculated quantity at 80 lbs. per cubic foot.

The contractor to cut all drains in the district from which his coal is wrought. If a tub of coals contain a cubic foot of stone or shale he forfeits the coal.

The contractor to pay two-thirds of the winding staff, and to supply, free of charge, all coal for the winding engines, ventilating purposes, and pumping engines, smiths' shops, and any other coal for lighting purposes. The contractor must not reduce or increase the wages paid to his men without the sanction of the Government.

Contractors will be allowed one shot for every 2½ tons wrought

in the whole mine, and in the broken mine, one for every three tons.

The contractor to provide all baskets, and oil for surface and underground lamps. Light the pit bottom, and white-wash the walls and roof, as often as the manager thinks fit, for a distance of 150 feet; provide two signalmen at each shaft, one at the top and one at the bottom of the pit, and lay and maintain all haulage work.

Manager to have power to give the contractor forty-eight hours notice to carry on the work himself at the contractors' expense, should the contractor fail to carry out the provisions of his contract.

Ten per cent. on all weekly payments due to the contractor to be deducted, as security, until 3,000 rupees have been so deducted."

The contract is for six months.

There is an arbitration clause and four clauses in which the Government are to pay certain tonnage prices and keep in repair all machinery and plant, supply all tools, give and supply timber for propping and gearing the roofs and walls of the mine. The contract and articles of agreement are printed in English, and rarely is a native able to read it; he only cares to know the rates and leaves the rest to his Kismet.

The contractor, on having signed his contract, has first to look about him for labour, which is, strange to say, very scarce, for all one reads of the teeming population of India. The pits have never, to the writer's knowledge, been properly filled with labour. The pits are kept working all day in three shifts of 8 hours, commencing at 6 a.m. In the first shift the workings are fairly filled, in the second, about half the places, and in the night shift, a quarter only filled with labour.

The labourers principally employed at the mine come from the North West Provinces, between Benares and Delhi, and belong chiefly to the Kurmi caste or the agricultural class. Also men of the Passi or pig-breeding caste, from the north-west, find work, but they rather make work in the pit a cloak to their thieving propensities, for they are the craftiest of thieves, and give the native police a great deal of trouble. One finds, too, a few natives of other castes from the north-west, such as the Ghararia caste, or sheep breeders; Chettris, soldier caste; Brahmins, priest caste; and Lallas, writer caste. Also Ghonds, an aboriginal tribe, Dhers and Chamars, local Hindu castes, are frequently met with. The Dher caste predominates among the latter.

Strikes are of very rare occurrence ; a short strike occurred when the trammers' hours were lengthened from six to eight hours, of about one day ; and another strike of two days occurred when the underground coolies were reduced. They were got over by discharging the ringleaders.

These men, if working under a contract, or employed under the Government, are allowed a piece of raised ground, or "chabootra," in the colliery files, within the boundary of the colliery property. The piece of ground is 25 feet by 20 feet square in some cases, 10 by 20 in other cases, and is raised a foot high; the dwellings are arranged in long rows, similar in appearance to colliery villages in England, and each caste kept in separate files. Each man is charged a ground-rent of 3 to 4 annas (3d. to 4d.) a month, according to the area of ground, and pays a grazing fee of 1 anna (1d.) a month per head of cattle he owns inside the colliery compound. Men not living in blocks, but living in huts of any size in the colliery ground, pay 1 anna a month. Also from all men who do not live in the colliery files, or colliery compound, but work in the shops or mines under the Government, is deducted one anna per month conservancy cess. The Government deducts from the contractors for his men these rents, and a conservancy cess of 1 pie ($\frac{1}{12}$ penny) per ton raised by them, which does not quite cover the cost of keeping the files and the pit workings in a sanitary condition. A coolie's hut is a very simple affair, consisting of a frame-work of bamboos, covered and walled in with tatties, which are screens made of split bamboos, which costs the native 3 rupees to 4 rupees (4s. to 5s. 9d.). His food consists chiefly of jawari, a native grain, parched, and chupatees, a sort of pancake made out of a coarse flour. Each hut stands separate, a space of about 4 feet being left between the huts. A fire commencing at one end of a file, with the wind in the right quarter, will burn the whole file in a short time. This has occurred frequently, and once on such an alarming scale one day that the workmen had to be called out to stop the fire spreading, by pulling a hut or two down to make a gap in the fire's course. The writer here noticed a curious feature in the native, the men of the neighbouring file would not assist at all, saying, on being accused of laziness and callousness, that if their huts had been on fire the others would not have helped them, and they remained contentedly looking on. After such a fire, a great rush is made to dig up the ground on which the huts stand, to get at the money they hoard. The lower castes do not sufficiently yet trust the Post Office

Savings Bank, of which every large village is possessed, and with the thriftiness peculiar of the oriental nature, in strong contrast to the extravagance of occidental people, they live on the simplest fare, dress in the scantiest manner possible, and hoard their savings, or invest it in silver jewellery which they wear about them. These files are watched very carefully, as regards sanitation, by the doctor of the colliery, assisted by a sanitation clerk. Numerous latrines are provided, also wells in the neighbourhood for water, but it is very difficult to get the natives to use the latrines and drink well-water. In fact, any European living in India can understand how cholera and other dire epidemics originate, and it is a wonder that cholera does not exist continually. They use the water for drinking and cooking purposes in which they first bathe and wash their clothes, in the calmest manner possible, and 90 per cent. of them never make use of the latrines provided for them. The water pumped from the mine, which is as dirty, both organically and inorganically, as can be, is preferred to well-water, because it is nearer and takes less trouble in procuring. How the coolies escape decimation in the rains, from fever and severe chills, is unaccountable, considering that they live in huts with a poor covering of bamboo matting, and sides of bamboo matting, cemented with cow dung, and floors of cow dung. In the mine, too, the greatest filth exists from the dirtiness of their habits. Lately, latrines were built underground, but they will not use them, punish them as you will, and the consequence is that the air, in many portions of the pit, is like that coming from a sewer. A class of men called sweepers have to be employed, who are of the lowest caste, and who are paid at the rate of 6 rupees per month, who travel the workings daily, in two shifts, and who clean away the filth, filling it in baskets and taking it to the surface, but the eighteen or twenty men so employed can hardly be said to be sufficient to look after the daily complement of men which, in busy seasons, numbers 1,200 men a day in three shifts. The natives loathe these sweepers, and will not ride in the same cage with them, their presence they declare is contaminating, and they reminded the author, when he first saw them descending the cage alone, of the non-union men in the North Country who are equally shunned by their union brother workers. The sweepers once struck work for a few days on their wages and number being reduced, and their hours of work increased, but a discharge of the ringleaders, and a threatened reduction all round, brought them to work again.

The contractor goes all round the villages and hunts up his men, who will not commence work unless advances have been made them of 2 to 3 and 5 rupees. The contractor also very often entices to work for him men working under another pit contractor—for there are generally four contractors at Warora—and then, of course, there is a row, and complaints reach the mining engineer, for, naturally, after giving a man an advance, they like to keep him until they have been recouped. The men have then to be provided with tools for the hewers, baskets and shovels for the trammers, and lamps for all underground men. The picks, pick-handles, and shovels the Government supply. The picks are from $2\frac{1}{2}$ to 3 lbs., and are of English make, known as Hardy's picks. The handles also come from England (for, strange to say, no wood has been found in the surrounding country equal to English ash or American hickory for pick shafts), and are from $2\frac{1}{2}$ feet to 3 feet long. In fact, all the tools are of English make. The contractor gets, besides, for odd work underground, from the Government, drills, scrapers, claw and hand-hammers, rail gauges, augers, sprags, wedges, chisels, adzes, hand-saws, and a leather bag for keeping rail nails in. For laying tramways he gets teakwood sleepers, and rail and dog nails, which his men waste terribly. The Government provide a smith to sharpen the picks, but the men bringing the picks must blow the bellows for the smithy fire. The hewers are paid 2 rupees 8 annas (3s. 4d.) per yard for driving winning places 7 feet wide and 5 feet high in coal, which is equal to 10·6 pence per ton. In ordinary headways in the whole mine they get 2 rupees 4 annas (3s.) per yard, equal to 9·6 annas per ton. In taking down a foot of top coal in winning places, the hewer is paid 12 pence per yard, which amounts to 5·3 pence per ton, and in ordinary 7 feet headways, for 3 feet of top coal, he gets 10 pence a yard, or 4·4 annas a ton. The bords are driven 12 feet wide, and the hewer is paid for driving them 2 rupees 12 annas a yard (3s. 8d.), equal to 6·845 pence per ton; for 3 feet of top coal in these places he gets 14 annas a yard, equal to 3·629 pence per ton, so that the contractor pays about 7 pence per ton for hewing in the whole mine, including oil, but he pays all his hewing by yard prices. It would be better could a tonnage price be fixed, but then weighing machines on the pit bank would have to be introduced; at present, the coal is only weighed in trucks at the weigh-cabin. To all underground men the contractor allows 4 oz. of oil per shift of 8 hours. A mixture of $\frac{1}{3}$ kerosene and $\frac{2}{3}$ castor oil is used, filled into

tin lamps, shaped thus, in which cotton wool is used as wick. The kerosene oil costs 1½ pence per lb., and the castor oil 2½ pence per lb. It would thus be cheaper to use kerosene, were it not that it smokes dreadfully in the way it is at present burnt, and, in fact, a lamp is much needed in which kerosene oil can be burnt without smoke. English lamp makers should turn their attention to this. Each lamp at present costs the contractors a little more than a ½-penny per shift for oil and wick. In winning places two hewers a shift are employed, and during 20 shifts per week the place is kept going, leaving only one shift vacant during the week, that being on Sunday afternoon, from 2 p.m. to 10 p.m., when all native labourers flock to the bazaar, the term given to the local market. All other places and workings only work 17 shifts per week, 5⅔ days continuous work, from 6 a.m. on Monday morning to 10 p.m. on Saturday evening.

The speed of driving in coal by native labour is very slow, six natives working eight hours per day, two men per shift working 20 shifts a week, will only advance a 7 feet wide winning place 5 feet high, 20 feet on an average sometimes running up to 25, and in one case reached to 30 feet. At 20 feet per week, which equals 25 tons, a hewer averages $\frac{2}{6}^{5} = 4{\cdot}16$ tons per week, or $4{\cdot}16 \div 6\frac{2}{3}$ shifts $= 0{\cdot}63$ tons per shift in eight hours, a lamentable contrast to our north-country hewer, who averages over 3 tons a shift of fewer hours. But this 20 feet per week can only be driven by extra rates, the contractors have again and again failed to do it at the ordinary rates, so that the clause in the contract for driving winning places has been reduced to 15 feet per week, which brings the tonnage per man per week to 3·12, and per shift to 0·47 tons. In the ordinary workings in the whole the contractor has trouble in keeping an advance of 9 feet per week, which in the case of a 7 feet gallery, with 3 men per day, comes to 2·81 tons a week, or nearly half a ton per man per shift working 5⅔ shifts per week. In the case of 12 feet galleries with six men per day and advancing 9 feet per week, the tonnage per man per week is about 3·21, or nearly 0·6 tons per man per shift.

While taking down top coal the tonnage per man is much greater, for no kirving is required. In the broken, the tonnage per man is greater also.

This small output per man will make it clear what difficulty exists in India in getting a large production. For 1,000 tons a day 2,000 hewers would be required, were there no broken worked and no top

coal, but taking 14½ per cent. of broken and top coal being worked wherever possible, the tonnage per hewer amounts to 1¼ nearly, and per trammer to 2 tons nearly. Taking a case that occurred on November 22, 1888, when 690 tons were raised, the number of men employed underground was :—

| | | Tons per Man. | Men per Ton. |
|---|---|---|---|
| Hewers ... | 554 | 1·24 | 0·803 |
| Trammers | 356 | 1·91 | 0·516 |
| Mates ... | 17 | | |
| Coolies ... | 57 | | |
| Shotmen | 8 | | |
| Boys ... | 51 | | |
| Onsetters | 7 | | |
| Total | 1,050 | 0·65 | 1·522 |

Of this 690 tons, 100 tons was raised from the broken, and of the whole coal a large portion was got from the top coal. From the above data, 1,000 tons a day will require ... 803 hewers
516 trammers
altogether, including off-hand men ... ... 1,522

This shows what a great amount of pit room is required for so large an output. Considering also that the pit works 24 hours a day, and that an extra shift cannot be introduced, that the rate of opening out is so slow, and that a great part of the top coal worked had been saved for six months during the slack and monsoon season, it can well be imagined that to secure a large output is no easy matter with a small number of pits—the larger the number of pits, the greater the number of winning places capable of being worked.

Before the author took charge of the colliery, no systematic method of working the broken was in practice. A few pillars had been worked some three years previously, by splitting them in all directions, and this was the extent of the broken mine, so he immediately introduced working the broken on a plan similar to that adopted at the Stella Coal Company's Colliery, by driving a jenkin, and working the 45 feet square pillars in two lifts off the jenkins, and two off the bords. Another plan was tried—to take the lifts off the headways—but found not to answer as well as the former method. At present the pillars are worked 60 feet square, and as no broken has, as yet, been worked in such pillars, it will probably be found best to work them off the headways.

The jenkin's price is 1 rupee, 8 annas (2s.) a yard, or 8·63 pence per ton. The top coal in it is paid at the rate of eight pence per yard, equal to 4·16 pence per ton for a 3 feet thickness of top coal, which in the broken mine is taken twice out of the top coal. Working off the lifts in the bottom coal costs 2 rupees, 8 annas, and 2 rupees 1 anna, (3s. 4d.) and (2s. 9d.) according to its being 12 or 10 feet wide. When the jud has been excavated in the bottom coal to a height of 4 feet, the roof is supported by strong props, and 6 feet of top coal is taken down carefully, by drawing some of the bottom coal props, and blasting the top coal. This is the most dangerous part of the broken working, for the jud becomes 10 feet high, and the timbering of such a high roof in a jud, 24 feet by 24 feet square, requires heavy props, and the roof careful watching. The taking down of this coal is left to so-called native "mates" equivalent to deputies in the North of England. Their pay comes to about eightpence per shift, and the coal so got costs twopence per ton. After deducting one-tenth for loss, the cost per ton to the contractor of the broken mine is $4\frac{1}{2}$ annas per ton for hewing.

The timber in the broken mine jud is drawn by the Government native mates, who have a bonus paid them at the rate of 1 anna (1 penny) per prop drawn, which cost the Government 3 rupees (4s.) on an average. These men have become very skilful, and generally get about 50 to 75 per cent. of the props, using only a heavy hammer and pick. No accidents have occurred in drawing props.

The hewer does not sit while nicking and kirving, he either stands, or more frequently squats on his heels or "hunkers," as it is termed in the North. In fact, all native workmen prefer this position. The carpenters, joiners, and the rest of them do not need benches to stand at, they do the work just as well on the floor, or if they have a bench they will squat on the bench.

The hewer also jumps his hole, which varies in size, from $1\frac{3}{4}$ inches to $2\frac{1}{2}$ inches diameter, for he never cares to see that he has his drill sharpened to the size required for the shots, *i.e.*, $1\frac{1}{2}$ inches diameter. They are a strange people: *en passant* it might be mentioned that the saws they use cut while the saw is pulled, the native prefers this way of sawing to the English method.

The Government, as said before, provide the shots for blasting and shot firers, and for this purpose a native shotman is employed at sixpence per shift, with a boy at threepence a shift who carries the shots for the shotman in a barrel which holds about 100 shots.

The shots are cartridges in cotton bags, made like sausages, holding about 6 to 6½ oz. of powder, to which is attached 3 feet of common blasting fuse. The shot is 1½ inches in diameter, and 6¾ inches long. The price of such a shot with gunpowder costing £2 10s. 8d. per cwt., at Warora is 2¾ pence. In 1887, the cost per ton for shots alone, including material and labour, and fuse, but excluding distribution, came to 1⅓ pence per ton. The present rate of consumption of powder is 2·4 oz., in the whole mine, and 2 oz. per ton in the broken mine. At present the Government are using the German compressed gunpowder from the United Rhenish Westphalian Gunpowder Mills at Cologne, which it is believed will be found cheaper than the loose powder now used. The shotman also travels with a jud gauge, which enables him to see if a jud has been properly kirved and nicked, the minimum depth of kirving and nicking being 3 feet, and height of kirving and width of nicking 18 inches. If the jud is not deep enough he is supposed not to give a shot to the hewers, but cases have occurred where the shotman levies backsheesh before giving a shot, and where the shotman gives shots for juds imperfectly made, which leads to much annoyance; on the whole, however, the system works well. The shotman loads, stems, and fires the shot himself, not more than one shot being allowed to be fired at one time in a jud, and drilling out of shots prohibited. Copper stemmers and beaters are used, carried by the shotman, and very few accidents occur in the operations.

The tramming comes next to be taken into consideration. The contractor pays on the tub trammed, at rates which vary according to the distance trammed, yet no specified distance exists for any rate. The contractor starts by paying as low a rate as possible, and keeps to it until the distance of his workings become so great from the shaft, that the men refuse to work at the rate, when he adds something to keep the work going, and the rates vary from 1¾ to 2½ per tub holding 10 cwt. of coals. All the coal at present is trammed by manual labour to the pit bottom, and the tramway is kept up to the face as much as possible. The maximum distance trammed is 2,000 feet at present, and the minimum 500 feet. Two men are always employed to tram, and sometimes, if the distance is great, or the road steep, three men. They also fill the tubs, and as they do not trust their neighbours, never leave their tools—shovels and baskets—behind, but carry them about.

The native trammer, although he uses a shovel, does not shovel the coal direct into the tub, but fills a light basket, holding about half a cubic foot, on the ground, which his mate empties into the tub. Again, however easy the road may be, two natives must always tram a tub; one man goes in front and walks backwards, dragging the tub after him, while his mate hangs on behind, shoving or holding back to suit the declivity of the road and speed of the tub. In this way innumerable accidents happen to trammers, for either the trammer runs into a ventilation door, damaging door, door-boy, and himself, or he stumbles when going fast down hill or round a corner, and his tub runs over him. In fact the trammers suffer by far the greater number of accidents underground. Every set of trammers are obliged to carry an iron sprag with them if the roads in any way need one, for generally they are careless, often using, if not looked after, small pieces of wood which often break, or neglecting to sprag at all when they either let the tub run "amain," damaging other men in front or injure themselves in trying to hold back the tub. The haulage roads are not sufficiently long enough to use any form of mechanical haulage with economy. Horses have been tried, but they, like the natives, are so weak, that although two horses are not required for one tub, yet one horse will only pull a single tub. Pit horses at Warora cost 17 rupees per month, including everything, food, attendance, repairs, and harness, &c. The haulage animal of the country, which is the bullock, has been tried working in a gin and hauling from the dip. They did very well, and might with economy be used when more dip workings are worked by working in gins.

In odd and off-hand work coolies are employed getting from fourpence to fivepence per day; they are under the charge of mates, equivalent to deputies in the North of England, and firemen in South Wales, who get from 10, 12, to 16 rupees per mensem (13s. 4d., 16s., 21s. 4d.), the latter being the standard salary for a Government mate, except one man, who really is a first-rate man, reliable and honest, who gets the magnificent salary of £2 per month (30 rupees). Some of these men understand English, and manage to understand a strange mixture of Hindustani, Marathi, and English spoken by the European subordinates, in which English oaths, mixed with dirty expressions made use of by the natives, figure frequently. When a coolie becomes a mate he thinks that his working days are over, and disdains to use his hands to work, except when a European official is present, when he immedi-

ately pretends to be working harder than anybody; he looks upon himself as a "sahib" much to be envied. It must be the climate, for laziness runs through these men's systems in a terrible way, and Europeans also, after a time, lose that energy which marks their character elsewhere. Among the native mates, of course, there are exceptions, and a few of them work very hard in their way, but always require careful supervision. They, and the coolies under them, look after the timbering, laying of roads, canvassing and coursing the air, cutting drains, and any odd job. It is no use leaving work to a batch of coolies to do without a mate over them, for they will idle away their time, and all the abuse and fining in the world will not be of any good; on the other hand the mate would feel too ashamed to be reduced to a coolie and have his pay cut down, and this wholesome fear makes him look after the work.

Next comes the European overman or deputy, of which one only is employed at Warora, who supervises the broken workings. His salary is 200 rupees per mensem (£13 6s. 8d.). Then a number varying from four to seven European underlookers are employed, generally soldiers from neighbouring regiments, who are allowed to work for one year at Warora if well behaved. These men generally have charge of a pit's workings, during a shift of eight hours. They get 75 rupees per mensem (£5), and free quarters as long as they are soldiers, and may rise to 120 rupees (£8) more if they can get their discharge from the army and work well at the pits. One remark is needed here, European subordinates are very difficult to manage in India, they will do no manual work like a deputy at home; they will only supervise. They illtreat the natives frequently, will not learn the vernacular, and are very discontented, especially those who are obtained direct from England, for they know that it takes a long time to replace them (as they are under covenant), and much trouble to get rid of them. Such men think when they reach India, and find they must keep servants, that they have hit on the royal road to fortune, and little they care for their work. This is the author's opinion, although he has had one or two good men who worked really hard and conscientiously.

On the surface, two Europeans are employed to look after the colliery machinery, one on 150 rupees (£10 13s. 4d.), and the other on 200 rupees (£13 6s. 8d.), a month. These men have been born and brought up in the country; therefore, their experience of

colliery machinery is exceedingly limited. A native surveyor on 60 rupees per mensem (£4) completes the subordinate establishment.

All clerks in the colliery office, which is at present combined with the Wardha Coal State Railway's Offices, are all natives, some Hindoo and some Mahomedan. Many of these speak and write English much better than the European subordinates, and are altogether superior men in education and business qualities; but they belong to the highest native castes and are the most educated of natives in India, with the exception of the doctors and lawyers and a few engineers. The salaries of the clerks vary from 15 rupees to 150 rupees per mensem. The draughtsman gets 90 rupees, tracer 15 rupees, head timekeeper 70 rupees, assistants (3) varying from 15 to 25 rupees, and 2 weigh clerks, one 45 and the other 30 rupees a month. A native surgeon is also provided by the Government for the employees, married persons paying him one week's salary per year for attendance on wives and children, otherwise his services and medicines are given gratis. His salary is 305 rupees per mensem, and he is assisted by a native compounder on 12 rupees per month.

A hospital with two beds, and a dispensary form part of the establishment. Besides there are a number of "peons" or "chuprasees," their equivalent in England being commissionaires, who are employed by all the superior establishments and clerks to carry messages. The officers each have one to carry their note book and foot-rule; besides, each subordinate European officer has a lamp boy who carries his lamp and note book underground and carries messages when occasion demands. These "peons" get 7 rupees a month, and the lamp boys 3 to 5 annas a day. The superior establishment of the colliery consists of a mining engineer on 600 rupees (formerly 700 rupees), an assistant mining engineer on 350 rupees, and the manager, who divides his attention between Warora and Umaria Colliery, who gets 1,000 rupees, half being debited to each concern. Now, also, the mining engineer has nothing to do with the surface establishment which is under the management of the manager of the Wardha Coal State Railway, on 650 rupees, and his assistant on 450 rupees. This is a strange procedure and lends itself to much trouble, expense, and annoyance. The surface machinery, as already described, being of no special design or expense, ought to come under the management of the mining engineer, who is accustomed to look after much better machinery in England.

Besides the above, there is a European blacksmith foreman on 300 rupees per mensem; a native sub-storekeeper, who manages the stores, on 110 rupees per mensem, assisted by four clerks on 70, 50, 30, and 15 rupees per mensem. In the stores are also four other men on 7 rupees per mensem.

Government colliery men are paid very irregularly; two to three weeks' pay is kept in hand, and no set dates or days are fixed for payments. Money is paid out to the men from bulk—not in boxes as practised in England—by a native cashier. Formerly, so many complaints reached the author that men were short in their pay, that he attended the pay once and found that the cashier cooly deducted all pies or twelfths of an anna, saying that the coins of ¼ anna, termed pies, were the lowest coins paid. Coins of pies do exist, but are rarely found. This was reported, and the cashier found to be wrong; and, after that, a European subordinate was made to attend payments and see fairplay. The time lost in paying, in the manner above indicated, is great, 200 or 300 men taking four to five hours to pay. The box system was last autumn introduced in the workshops, and will, no doubt, be introduced for colliery labour shortly.

## THE SYSTEM OF WORKING THE COAL.

The method of working is the bord and pillar system, which was formerly in the old days, prior to 1883 anyhow, with pillars, 20 feet square, bords and headways 12 feet wide, and 12 feet high, resulting in a general collapse of the roof, and facilitating the loss of the greater part of No. 2 Seam, near No. 2 Pit, by fire. These old workings are now totally lost, they are walled in by brick and basalt walls, hermetically sealed, in which fire and the crushing in of the roof and pillars have played sad havoc. The area thus lost amounts to 30 acres, in which 50 per cent. of the available coal has been worked. A little longwall was tried in 1876, but given up, and the fire is believed to have originated in the goaf of this longwall. From 1883, the pillars in No. 2 Seam and No. 3 Seam were made 45 feet square, with 12 feet bords running against the cleat and parallel to the strike, and the headways 7 feet, parallel to the dip of the seam, and in 1886 it was decided to increase the pillars to 60 feet, leaving the bords and headways as before. The broken has as yet only been worked in the top seam or No. 2 Seam, it being thought best to work the top seam broken first.

The broken is worked in lifts off jenkins. A jenkin being a narrow drive up the centre of a pillar in the same direction as the bords.

All the coal is worked in the bottom portion of the seam; the seams are 15 to 16 feet thick when fully developed, and the roof, which is a soft and friable shale, weathers very much, so much as to necessitate coal being left as a roof, and the shale roof is never exposed. At first all the levels and gallaries are driven in the thill of the seam, 5 feet high, and in the slack season of the year, that is, during May, June, July, August, September, and October no top coal is touched, but saved for the busy season. It is then that hewers average from 10 to 12 cwt. per shift of 8 hours, in the whole mine. During the busy season, in all the galleries, 3 feet of top coal is taken down, raising the height of the galleries to 8 feet, leaving still from 7 to 8 feet of coal in the roof. This remaining coal in the roof is not touched until the broken is worked, when from 3 to 4 feet more is taken down, so that really only two-thirds of the seam are worked, leaving one-third unworked and untouched. This seems a terrible waste of coal, thirty-three per cent. being entirely lost without any attempt at winning; but, on the other hand, the roof of No. 2 Seam which often runs into a soft, clayey sand, would swamp the pit if the whole thickness of the seam were worked and the roof exposed, and as the roof, even at its best is so bad and apt to fall in a short time in small, broken, or crushed pieces, and let in the water of the upper strata, this waste is thus thought to be smallest by working the coal as at present. It remains to be seen whether any more of the top coal can be won in the bottom seam broken, but considering that there are only 5 to 7 feet of intervening shaly strata, great doubt exists, Besides, timber is expensive at Warora, the props, which are from 8 feet to 14 feet long, and vary from 8 inches to 12 inches diameter, costing 3 rupees (4s.) a piece, an extravagant sum; so that if more top coal is to be taken down, longer and heavier props will be necessary and the expense of timbering raised.

It is also intended that the new workings in panels, now being opened out, should be worked in both seams, in the whole and broken mines simultaneously, or at all events the broken, the top seam a little in advance. To guard against underground fires spreading, the coal, by the author's orders, is worked in panels containing 4½ acres of coal (about), surrounded on three sides by a barrier 60 feet thick, the other side having seven openings which

can be walled off in case of fire, or in any case as soon as the panel has been laid down in the broken. This area of 4½ acres is about the area got at by experience, which can be worked before fire in the goaf appears. From the above remarks, the waste in working can be tabulated as under:—

| Size of pillars. | Thickness of seam in feet. | Coal lost as top coal. Percentage. | Coal worked in the whole mine. Percentage on total thickness (of 15 ft.) | Coal worked in the broken mine. Percentage on total thickness (of 15 ft.) | Waste allowed in working the broken. Per cent. | Total Amount. | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Won per cent. | Lost per cent. | Total. |
| 20 ft. square | 15 | 33·3 | (1) 41 | nil | — | 41 | 59 | 100 |
| 45 ft. pillars | 15 | 33·3 | (2) 22 | 33 | 25 | 55 | 45 | 100 |
| 60 ft. pillars | 15 | 33·3 | (3) 16½ | 42 | 15 | 58½ | 41½ | 100 |

(1) 61 per cent. of the workable or lower 10 ft. of the seam is worked in the whole mine.
(2) 33 ,, ,, ,, ,, ,,
(3) 25 ,, ,, ,, ,, ,,

It will, therefore, be seen that the waste in working has been reduced from 59 to 41½ per cent. of the total thickness of the coal in the two seams since 1883, and this waste may still be reduced should little difficulty be encountered in getting more top coal when working the No. 3 Seam large pillars in the broken.

The seams dip to the extent of 1½ inches per yard, S. 64 E., and in the northern portion of the workings, near No. 5 Pit, a fault throws the strike of the seam, almost due north and south, and the seam dips 3 inches per yard.

The magnetic north and true north almost coincide at present; the magnetic variation is 2 deg. 22 min. 20 sec. east of true north, increasing towards the east yearly.

Native trammers being so weak, dip working is almost entirely at a standstill for want of some motive power to haul coals from the dip. Driving dip cross-cuts gets over the difficulty to a certain extent, but they are not always applicable. Water, too, is a nuisance in dip workings. At present it may, therefore, be said that only rise coal is worked, and what dip coal there is will have to be worked from deeper pits to the dip.

The writer thinks that the longwall system of working in such thick seams, so near together and liable to spontaneous combustion, is impracticable. In 1876, longwall was introduced by Mr. Ness,

a mining engineer of some experience of the system of longwall, but it was abandoned by him in 1877. Shortly after it was given up, a fire occurred, caused by spontaneous combustion in the longwall goaf.

Very little timbering is required in the whole mine, the coal left in the roof acts as a remarkably good roof—in fact, in the workings opening out at the last pit, No. 5, there is hardly a prop to be seen in the whole mine, either in bords or headways. The bords here are started narrow and widened out after 6 feet has been driven. In the broken rather much timber is required, and the height of the roof necessitates long and heavy props, which are very awkward to handle with native labour, four to six coolies being required to carry, hold, and set a prop. The timber in the old workings decays very soon from the excessive moisture in the air; but dry rot is rarely seen in the timber.

## COST OF TIMBER.

All the timber used is in the shape of props cut in the Government preserved forests, near Chanda, about 30 miles south from Warora. Timber in India is very expensive; teakwood costs $3\frac{1}{2}$ rupees (4s. 8d.) a cubic foot, and is the only timber available for ordinary work. Before 1883 very few props were used, and it was only on the introduction of a regular system of working and commencing the broken mine that the getting of timber on a large scale was gone into. In January, 1884, the Government Forest Department sent six sorts of timber, in the shape of props, for trial, the principal variety being Garrari (Lepidopteris orbicularis), of which the props up to that time had been. The others were Thendu (Diospyros melanoxylon), Dhaora (Anogeissus latifolia), Mohka (Schrebera Swietenoides), Aouli (Phyllanthus emblica), and Seena (Lagerstromia pariflora). Of these, Garrari was given up later, after trials with it in the pit; its wood is too fibrous, and it was found too flexible, and very often hollow. Thendu was found to be the best; it has as heart wood, ebony, and was found to answer well as a prop in the broken.

Dhaora was found to be the next best, but its curious structure, in which the fibres looked like the twist of the strands in a hemp rope, made it less fit to stand pressure. Mohka was found to be a fair timber, while Aouli and Seena were pronounced bad. Unfortunately a large number of Garrari props had already been

ordered, and they became of use by being split and used as lagging; Garrari is also more plentiful than other timber, being a quick growing tree. After this, two sorts only were ordered—Thendu and Dhaora with a little Garrari. Then the Forest Department complained that at the rate of our consumption, the timber we preferred could not be supplied without endangering the existence of the plantations, and asked that some other kinds of timber be tried for pit props, and accordingly, a further assortment came and were tried. They were:—

1.—Rohan (Soymida febrifuga)

2.—Saj (Terminalia tomentosa); locally known as Ain or iron wood.

3.—Mohka (Schrebera swietenoides)

4.—Suria (Xyla dolabriformis)

5.—Bahera (Terminalia bellerica)

6.—Kahu or Argun (Terminalia arjuna); rather rare

7.—Kini (Albizzia procera)

8.—Bhirra (Swietenia chloroxylon)

9.—Chichwa (Albizzia odoratissima); not recommended by the Forest Department for pit work

10.—Mohwa (Bassia latifolia); not recommended by the Forest Department for pit work

Of all these specimens, Saj was the only additional timber recognized as good for mining, and accordingly from that date (1886), two sorts of props only were indented for Thendu and Saj. In 1888, the Forest Department complained again that if the colliery would still insist on being supplied only with two sorts of timber in such large quantities—about 5,000 props per annum, from 8 feet to 14 feet long, by 8 inches to 12 inches in diameter—they would be unable to keep up the supply, and again asked that other timber should be tried, and in November, 1888, eight samples were sent, of which three had already been tried, the others being—

Bhirra or satinwood (Chloroxylon Swietenia)

Kate or Kasei (Briedelis retusa)

Hiwar or Kinj (Acacia eucophlea)

Siras (Albizzia lebbak)

Keni or Gorarh (Albizzia procera)

and here the question stands. The timber is divided into three classes as follows:—

| Class. | Length. | Average diameter at thick end. | Number ordered, 1887-88. | Average cubical contents per prop. | Price per prop. | All round rate agreed upon in 1877. |
|---|---|---|---|---|---|---|
| | | | | Cubic Feet. | R. A. P. | |
| I. | 8 ft. to 9 ft. | 8 in. | 800 | 2·695 | 1 10 0 | R3 per prop |
| II. | 10 ft. to 12 ft. | 10 ,, | 5,350 | 4·792 | 2 14 0 | |
| III. | 13 ft. to 14 ft. | 12 ,, | 1,350 | 7·006 | 4 4 0 | |
| | | | 7,500 | | | |

Formerly, up to 1887, the timber was paid at the rate of 9 annas per cubic foot delivered on the colliery premises.

The following numbers of props were used in 1885-86 and 1886-87:—

| | 1885-86. | 1886-87. |
|---|---|---|
| Garrari ... ... | 2,289 | 738 |
| Thendu ... ... | 2,334 | 2,431 |
| Dhaora ... ... | 80 | 356 |
| Ain ... ... | ... | 176 |
| | 4,703 | 3,701 |

and in 1887-88,

| | | R. | A. | P. |
|---|---|---|---|---|
| Thendu and Ain ... ... | 3,558 ... | at 3 | 0 | 0 |
| Garrari ... ... ... | 522 ... | 1 | 13 | 0 |
| Thendu ... ... ... | 373 ... | 2 | 2 | 9 |
| Dhaora ... ... ... | 270 ... | 2 | 0 | 0 |
| | 4,723 | | | |

And for the year 1887-88, ending June 30th, the timber used in the pit in the shape of props, cost 1·8 pence per ton. The estimated requirements for 1888-89 are put down as under:—

| | |
|---|---|
| Class II. ... ... ... ... ... ... | 5,000 |
| Class III. ... ... ... ... ... ... | 500 |
| | 5,500 |

There is no doubt that the panel system of working, and the careful seeing to that no more than 8 feet of coal is worked in the whole mine, and the galleries kept their ordered width, and the narrowing of the bords of the headways, will still reduce the cost of timber per ton, especially when the broken is commenced in the large 60 feet pillars. The cost could be brought down to 1½d. or 1¼d. per ton.

The timber for props should be cut in or before the rains, and after barking, allowed to lie two or three months in the jungle.

## ACCIDENTS.

Fortunately, serious accidents are very rare at Warora. Under the Indian Factories Act, when an accident occurs and the injured person will not be able to return to work within 48 hours after the injury, a report must be sent to the magistrate of the district, the Inspector of the Factories Act in the district, to the Secretary of the Public Works Department to the Chief Commissioner, the head of the Local Government. In case of fatal accidents, the local police officer makes an enquiry and holds an inquest, with a jury selected by the police officer, among which a colliery subordinate has been known to act as foreman. According to the Local Government's orders, accidents are divided into four classes: fatal, serious, severe, and slight; and in 1886 the Local Government called for reports on all accidents, if the injured man could not work within the 48 hours stipulated by the Factories Act. Before that date only accidents of real importance were reported, so that the tables given in this paper of the accidents that have occurred prior to 1887 appear scant of information. Every accident, however slight, is reported to the doctor and mining engineer, and the subordinate sends to his superior officer a filled-in form giving details of the accident. The doctor makes a separate report, which is sent to the mining engineer, and he, the mining engineer, sends it on if necessary under the Factories Act. It, therefore, all depends on the doctor how he looks upon slight accidents, and although statistics show that all non-fatal accidents have been increasing, the writer is quite sure that had the former native doctors been so particular as to the 48 hours' clause as the present, non-fatal accidents would have shown a very little increase.

As to fatal accidents, none occurred underground in 1883 and 1884; in 1885 two occurred in the broken, by which two men were killed, not in the jud, but to men while tramming from the broken. They were killed by falls of side and top coal, the pillars having become shaken and showing a tendency to scale off, through the pressure caused by pillars next them being worked in the broken. In 1886 also, two trammers were killed, very much in the same way, in the broken.

In 1887 no fatal accident occurred, and in 1888 one fatal accident took place at No. 6 Pit, by two men falling from the surface to the bottom when taking off a rotten scaffold, this caused by the neglect of the engine foreman in not carrying out orders. In 1883, at the surface, a man was killed. The colliery in the past six years had to record four deaths from fall of top and side coal, two from falling down shaft, and one on the surface; altogether, seven.

In 1883 and the early part of 1884 frequent accidents occurred from blasting with gunpowder, which ultimately led to the introducing of rules to be observed by shotmen, and the rest of the rules drawn up by the writer for the colliery. Only one has occurred since. Latterly accidents to trammers—mostly slight—have occurred with frequency. They are due to the carelessness of the men in not using iron sprags provided for them, in running in front of the trams, getting caught between trams and wall side, and allowing the trams to run over their toes:—the native workmen underground wear no boots or shoes. Next, as regards frequency, are falls of roof, which have occurred in the working places only and not in the travelling or air roads.

The following table shows in detail the number of all classes of accidents for the past six years:—

## ACCIDENTS AT WARORA COLLIERY DURING THE YEARS 1883, 1884, 1885, 1886, 1887, AND 1888.

| Year. | Class. | Explosion of Fire-damp. | Falls in Mines. | | | In Shafts. | | | | | | | | | Miscellaneous Underground. | | | | | | | | | On Surface. | | | | Gross Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Falls of sides. | Falls of roof. | Total Falls. | Over-winding. | Ropes and chains breaking. | Whilst descending or ascending by machinery. | Falling into shaft from surface. | Things falling from surface. | Falling from part way down. | Things falling from part way down. | Miscellaneous in shafts. | Total in shafts. | Explosions by gunpowder. | Suffocation by gases. | Irruption of water. | Falling into water. | On inclines and engine planes. | By trains and tubs. | By machinery underground. | Sundries underground. | Total miscellaneous underground. | By machinery on surface. | Boilers bursting. | Miscellaneous on surface. | Total on surface. | |
| 1883 | Fatal | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | 1 | 1 |
| | Serious | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | 1 |
| | Severe | ... | ... | 1 | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | 2 |
| | Slight | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 1884 | Fatal | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | Serious | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 | ... | ... | ... | ... | ... | ... | ... | 2 | ... | ... | ... | ... | 2 |
| | Severe | ... | ... | 1 | 1 | ... | ... | 1 | ... | ... | ... | ... | 1 | 1 | 1 | ... | ... | ... | ... | 3 | ... | ... | 4 | ... | ... | ... | ... | 6 |
| | Slight | ... | ... | 1 | 1 | ... | ... | 1 | ... | ... | ... | ... | 1 | 1 | ... | ... | ... | ... | ... | 1 | ... | 2 | 3 | ... | ... | ... | ... | 5 |
| 1885 | Fatal | ... | 2 | ... | 2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 |
| | Serious | ... | 2 | ... | 2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 |
| | Severe | ... | 1 | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 |
| | Slight | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | 1 | ... | ... | ... | ... | 1 |
| 1886 | Fatal | ... | ... | 2 | 2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 |
| | Serious | ... | ... | 2 | 2 | ... | ... | ... | ... | ... | ... | ... | 1 | 1 | ... | ... | ... | ... | ... | 2 | ... | 1 | 3 | ... | ... | ... | ... | 6 |
| | Severe | ... | ... | 1 | 1 | ... | ... | 1 | ... | ... | ... | ... | ... | 1 | 1 | ... | ... | ... | ... | 1 | ... | ... | 2 | ... | ... | ... | ... | 4 |
| | Slight | ... | 1 | 2 | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 5 | ... | 1 | 6 | ... | ... | ... | ... | 9 |
| 1887 | Fatal | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | Serious | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | 1 | ... | ... | ... | ... | 1 |
| | Severe | ... | 2 | 6 | 8 | ... | ... | ... | ... | ... | 1 | ... | ... | 1 | ... | ... | ... | ... | ... | 6 | ... | 6 | 12 | ... | ... | 2 | 2 | 23 |
| | Slight | ... | 5 | 7 | 12 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 12 | ... | 5 | 17 | ... | ... | ... | ... | 29 |
| 1888 | Fatal | ... | ... | ... | ... | ... | ... | ... | 2 | ... | ... | ... | ... | 2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 |
| | Serious | ... | ... | 3 | 3 | ... | ... | ... | ... | ... | ... | ... | 1 | 1 | ... | ... | ... | ... | ... | 3 | ... | ... | 3 | 1 | ... | 1 | 2 | 9 |
| | Severe | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | 5 | ... | 1 | 6 | ... | ... | 1 | 1 | 8 |
| | Slight | ... | ... | 5 | 5 | ... | ... | 1 | ... | ... | ... | ... | 1 | 2 | ... | ... | ... | ... | ... | 12 | ... | 5 | 17 | ... | ... | ... | ... | 24 |
| | Total | ... | 13 | 31 | 44 | ... | ... | 5 | 2 | ... | 1 | ... | 3 | 11 | 6 | ... | ... | ... | ... | 51 | ... | 22 | 79 | 1 | ... | 5 | 6 | 140 |

During the six years there were 140 accidents of all classes, of which 7 were fatal, or 5 per cent., 21 serious, or 15 per cent., 44 severe, or 31·5 per cent., and 68 slight, or 48·5 per cent.

Again, 44 accidents happened through falls in the mines, or 31·5 per cent., 11 in shafts, or 7·8 per cent., 79 by miscellaneous accidents underground, or 56·4 per cent., and 6 on the surface, or 4·3 per cent. Again, 13 occurred by falls of sides (2 fatal), or 9·3 per cent., 31 by falls of roof (2 fatal), or 22·1 per cent., 5 by descending or ascending the shaft, or 3·5 per cent., 1 by falling from part way down a shaft, or 0·7 per cent., 3 by miscellaneous accidents in shafts, or 2·2 per cent., 6 by explosions of gunpowder, or 4·3 per cent., 51 by trams and tubs—by far the most numerous source of accidents, or 36·4 per cent., and of which 31, or about two-thirds, were slight accidents, 22 by sundry underground causes, or 15·7 per cent., and by machinery on surface, or 0·8 per cent., 5 by miscellaneous on surface (1 fatal), or 4·3 per cent.

During 1888, 1,250 persons a day were employed in the colliery on an average, which gives 1 death by accident to every 625 employed per annum, and, taking the average number of people employed during the past six years to be 1,150, and taking the deaths during the last six years, an average of 986 persons are employed per death by accident per annum, a remarkably good result, considering that the labour is raw and unaccustomed to the work, ignorant, and exceedingly careless—in fact, the people have to be looked upon as children. You have to tuck their clothes about them when they ride in the cage, for fear their clothing fouls the guides—one man got his arm broken in such a way. Last year's output amounted to 134,236 tons, or 1 death by accident to 67,118 tons raised, a rather disappointing result after the other, but is accounted for by the small output per man compared with England, and the consequent greater number of men to be employed in proportion to the output than in England. To make this figure comparable with England, we should multiply the tons raised per death by accident in India by at least three, because an average Englishman can at least do three times as much work as an Indian native, and we would only require one-third (at the most) of that number of Englishmen to get the same output obtained now in India.

During the past six years, 642,126 tons were raised, or 1 death by accident for 91,732 tons raised.

On the whole, one is struck very much by the (comparative) great

safety of coal-mining at Warora. The underground fire—that terrible incubus of Warora—has not even claimed a single victim during the last six years. In 1882, two lives were lost through it, one of the victims being the mining engineer of the colliery.

Prior to 1883, the following fatal cases occurred :—

| | |
|---|---|
| 1882 | 2 men lost their lives through the fire in No. 2 Pit. |
| 1881 | 1 man killed by falling down the pit. |
| 1878 | 1 man killed by falling down the pit, while doing repairs. |
| 1877 | 3 men killed. |
| 1876 | 1 man killed by jumping out of cage. |
| Total | 8 |

These are the only deaths recorded since 1870-71, the date of commencing operations at Warora. During these 12 years, 293,391 tons of coal were raised, the first output of importance occurring in 1875-76, or one life lost for every 36,674 tons raised. Compared with these earlier years, the last six years show a very marked improvement.

During the latter half of last year, the pit subordinates have attended lectures given by the Assistant-Surgeon on Sunday mornings on ambulance work, and the dealing with accidents underground; also, a complete set of ambulance requirements have been made on the most approved pattern for use at this colliery.

NUMBER OF PERSONS EMPLOYED AT THE COLLIERY.

In 1877-78 330 persons were employed.

In 1878-79 463 „ „ „

During the latter part of 1888, the men employed were as under per day of three shifts of eight hours each.

| | | Per cent. | | | Per cent. |
|---|---|---|---|---|---|
| Underground Men ... | 970 | 76·7 | | | |
| Boys ... ... ... | 80 | 6·3 | ... 1,050 | ... | 83·0 |
| MEN ABOVEGROUND. | | | | | |
| On Pit Heaps ... ... | 42 | 3·3 | | | |
| Women do. ... ... | 8 | 0·7 | | | |
| Enginemen, Firemen, &c., | 165 | 13·0 | ... 215 | ... | 17·0 |
| | 1,265 | 100·0 | 1,265 | | 100·0 |

During the past six years, the average daily number of persons employed would not be far off 1,150. The women employed only figure for 0·7 per cent. in the total number of persons employed, and those on the surface alone. Warora is the only colliery in India where no women are employed underground.

## OUTPUT OF WARORA SINCE IT WAS OPENED OUT.

Operations were commenced at Warora in the financial year ending 31st March, 1872, when, during the year, capital to the extent of 69,852 rupees was expended. Five years after the financial year 1876-77, coal was first raised to any considerable extent when the output was 10,700 tons. The capital reached 694,872 rupees, minus its interest or 792,517 rupees, including charges on interest or £52,834. This represented three pits. However, the financial part of this concern will be treated later on. In dealing with the following figures, it must be borne in mind that the output is put down per calendar year instead of financial ones.

| Financial year. | | | Tons. | |
|---|---|---|---|---|
| Output in | 1875-76 | ... | 1,200 | |
| „ | 1876-77 | ... | 10,700 | |
| „ | 1877-78 | ... | 40,786 | |
| „ | 1878-79 | ... | 41,248 | |
| „ | 1879-80 | ... | 32,099 | |
| „ | 1880-81 | ... | 25,692 | Cwts. |
| „ | 1881-82 | ... | 68,156 | 8 |
| Calendar year | 1882 | ... | 73,510 | |
| „ „ | 1883 | ... | 95,737 | 5 |
| „ „ | 1884 | ... | 94,721 | 8 |
| „ „ | 1885 | ... | 98,586 | 5 |
| „ „ | 1886 | ... | 108,129 | 10 |
| „ „ | 1887 | ... | 110,715 | 10 |
| „ „ | 1888 | ... | 134,236 | 10 |
| Total coal raised at Warora since its commencement | ... | ... | 935,517 | 16 |

1882 was the first year in which the output equalled the demand.

## THE SELLING AND GETTING PRICES OF WARORA COAL.

The greatest user of Warora Coal is the Great Indian Peninsular Railway Company; they find it a good and cheap fuel for their goods trains—on their mail trains only Welsh Coal is used. In 1877, the Great Indian Peninsular Railway Company agreed to take 50,000 tons of large coal per annum at 5 rupees (6s. 8d.) per ton from April that year to April 1884. From April 1884 to December 31st, 1887, the rate was reduced to 4 rupees 8 annas (6s.) a ton for 50,000 tons per annum. From January 1st, 1888, the rate has been further reduced to 4 rupees 4 annas (5s. 8d.) a ton for 72,000

tons per annum, to be delivered in monthly quantities of 7,000 tons during the busy season, *i.e.* November, December, January, February, March, and April, and 5,000 tons per month during the slack season or rest of the year. This rate holds good yet.

The next largest consumers now, are the Bengal and Nagpore Railway Company, who, for 1889, require in the first half-year large coal to the extent of 18,200, and 2nd 16,200 or a total of 34,400 tons at 4 rupees 8 annas (6s.) a ton.

Then comes the Wardha Valley State Railway, which, for 1889 requires 3,900 tons, of which 200 tons is small coal; they get the coal at cost price, and this was estimated at 4 rupees (5s. 4d.) a ton for the half-year ending 31st December, 1888.

Then next in importance come the Cotton Mills in the neighbourhood; these are the Empress Mills, Nagpore, Hinganghat Mill Company, and Budnera Mill Company. These firms use small coal only, and occasionally are forced to use large, when the demand for small coal exceeds the supply. In 1880 these companies were charged 7 rupees per ton (9s. 4d.) for large coal, and 2 rupees (2s. 8d.) for small coal. In October, 1880, the large coal was increased to 9 rupees (12s.) a ton, and the small coal in 1882 sold to these customers, was increased to 4 rupees a ton (5s. 4d.) and an unscreened class of coal introduced at 7 rupees 8 annas (10s.) a ton. In July, 1883, for a short time, unscreened coal was sold to one of the above customers at 6 rupees 3 annas (8s. 3d.) a ton for 2,000 tons in three months. In 1884, unscreened coal was abolished, and from January, 1884, up to January, 1889, those customers taking 5,000 tons or under per annum, were charged:—

| | R. | A. | PER TON. S. | D. |
|---|---|---|---|---|
| Large Coal ... ... ... ... | 5 | 8 | (7s. | 4d.) |
| Small „ ... ... ... ... | 3 | 8 | (4s. | 8d.) |

and when taking over 5,000 tons per annum.

| | | | | |
|---|---|---|---|---|
| Large Coal ... ... .. ... | 4 | 8 | (6s. | 0d.) |
| Small Coal ... ... ... ... | 3 | 0 | (4s. | 0d.) |

These Mill Companies take about 19,000 tons a year.

Other retail customers were charged, in 1880, 9 rupees per ton (12s.) for large coal, and 3 rupees (4s.) a ton. The small coal was increased to 4 rupees a ton (5s. 4d.) in 1882, and unscreened at 7 rupees 8 annas (10s.) a ton; and from 1st January, 1884, the higher of the above rates was charged, that is, 5 rupees 8 annas, and 3 rupees 8 annas for large and small coal respectively, except that

sold to State Railways and Government Departments which is at the rate of 5 rupees 8 annas and 3 rupees respectively, for large and small coal.

The railway carriage of coal is 4½ pies per ton per mile, equal to one-third of a penny per mile, or for 100 miles 2 rupees 5 annas 6 pies (3s. 1½d.) a ton, and as the Great Indian Peninsular Railway Company is 45 miles by rail from Warora, the coal costs them at this junction 1 rupee 10½ annas (1s. 5d. nearly) per ton more than the rate at the pit's mouth.

The Bengal and Nagpore Railway Company's coal has to travel 100 miles nearly, before reaching their line, thus increasing the rate of their coal at their terminus by 2 rupees 6 annas 6 pies (3s. 1½d.) nearly, the exact distance being 93 miles.

The above selling rates per ton represent prices at the pit's mouth.

COST OF GETTING OR RAISING.

| | Per Ton. A. | R. | P. | |
|---|---|---|---|---|
| For the financial year ending March 31, 1888, the cost was ... ... ... ... | 3 | 9 | 4 | (4s. 9⅓d.) |
| Do. do. March 31, 1887... | 2 | 8 | 11 | (3s. 5d.) |
| Do. do. do. 1886... | 3 | 2 | 5 | (4s. 2½d.) |
| Do. do. do. 1885... | 2 | 14 | 11 | (3s. 11d.) |
| Do. do. do. 1884... | 2 | 15 | 10 | (4s. 0d.) |
| Do. do. do. 1883... | 3 | 10 | 10½ | (4s. 11d.) |
| Do. do. do. 1882... | 4 | 3 | 9 | (5s. 7¾d.) |

The great increase in the cost of the last nine months of 1887 and first three months of 1888 was due to increase in the cost of ventilation and pumping, to an outbreak of fire in the early months of 1887, securing of No. 2 Pit shaft, and difficulties with water in No. 5 Pit.

It was really only in 1884 that the colliery could raise effectually all the coal required for customers.

EARNINGS, PROFITS, &c.

At the close of the financial year 1878–79 the Warora Colliery was treated as a separate concern, but from April 1st, 1879, the colliery and Wardha State Railway were treated as one concern. In 1888 they were separated again.

The Revenue accounts as they stood in 1882–3 showed a net loss to the Government for the colliery of 62,724 rupees (£4,182),

and adding interest to the capital sunk, this was 344,569 rupees (£22,971); and the Government determined to write back in the financial year of 1884 267,112 rupees from revenue to capital on account of charges for machinery having been debited to revenue instead of capital, so that at the end of the year 1883, the capital account of the colliery stood at—

| | Rupees. | |
|---|---|---|
| | 616,120 | (£41,075) |
| This sum reached in 1884 ... | 1,000,936 | (£66,691) |
| 1885 ... | 1,014,308 | (£67,620) |
| 1886 ... | 1,081,533 | (£72,102) |
| 1887 ... | 1,106,553 | (£73,370) |

Up to 30th June, 1888, the capital outlay of the colliery from commencement of operations stood as follows:—

| | R. | A. | P. |
|---|---|---|---|
| Works ... ... ... ... ... | 740,374 | 5 | 10 |
| Establishment ... ... ... ... | 162,524 | 14 | 5 |
| Tools, Plant, and Machinery ... ... | 208,865 | 14 | 3 |
| | 1,111,765 | 2 | 6 |
| Deduct receipts on capital account ... | 1,806 | 4 | 2 |
| | 1,109,958 | 14 | 4 |

Or £74,000 nearly at the present rate of exchange, which is a very moderate capital indeed, even if taken at par exchange rate.

THE NET RESULTS OF THE WORKING OF WARORA COLLIERY, FROM THE COMMENCEMENT OF OPERATIONS TO 30TH JUNE, 1888.

| | R | A. | P. | | R | A. | P. |
|---|---|---|---|---|---|---|---|
| Interest on capital outlay from commencement of operations to 31st December, 1887... | 447,439 | 10 | 8 | Net earnings of the colliery during the half-year ending June 30th, 1888... | 55,849 | 8 | 6 |
| Interest for half-year ending 30th June, 1888 ... ... | 22,207 | 15 | 8 | Net earnings of the colliery from the commencement of output to 30th December, 1887... | 742,933 | 14 | 7 |
| | 469,647 | 10 | 4 | | | | |
| Balance being surplus profits ... | 329,135 | 12 | 9 | | | | |
| Total ... | 798,783 | 7 | 1 | Total .. | 798,783 | 7 | 1 |

The above profit does not include what has been put by towards the sinking fund, established in 1884 for the redemption of the

capital which is debited to cost of raising and not profit. It is levied by charging and laying aside a rate of 5 annas a ton (5d.) on large coal and 2 annas a ton (2d.) on small coal raised. This fund at the end of 1886 amounted to 94,048 rupees (£6,270 nearly).

The above profit of 329,136 rupees (£21,942) represents the profit from the commencement of operations since 1871 up to 20th June, 1888, that is, for 17 years or an average of $1\frac{3}{4}$ per cent. per annum on the capital, or $29\frac{1}{2}$ per cent. extending over the whole period. This is not encouraging from a financial point of view, but the Government are in a measure to blame, for there being no competition, the prices could be raised 1 rupee a ton.

The State, however, does not wish to make any large profit on the concern, and as long as its capital is safe, a moderate return is what it looks forward to.

The result of the last seven years is very encouraging financially, and stands as under:—

| Financial Year. | Profits. Rupees. | Per Cent. |
|---|---|---|
| 1887—8 | 75,612 | 6·83 |
| 1886—7 | 115,196 | 10·65 |
| 1885—6 | 97,414 | 9·6 |
| 1884—5 | 112,334 | 11·22 |
| 1883—4 | 174,948 | 28·39 |
| 1882—3 | 126,290 | 12·9 |
| 1881—2 | 13,812 | 9·6 |

The total loss up to the end of 1882-3 to the State, that is the net revenue, fell short of the interest charged by 76,145 rupees.

| | | Rupees. | |
|---|---|---|---|
| 1880—81 | Loss incurred was | 195,084 | |
| 1879—80 | „ | 50,000 | |
| 1878—79 | Profit made was... | 58,730, or 8·3 °/₀ | in capital. |
| 1877—78 | „ | 64,064, or 9·2 °/₀ | „ |

The profits from 1884 have not been so great, but that is owing to the selling prices of coal being reduced from 9 rupees to 5 rupees 8 annas, and 4 rupees 8 annas, a reduction of almost 50 per cent. in the former case. Again, as the price of silver keeps falling year by year, and no addition is made to the selling price, profits will get less; for all materials used at this colliery, which cannot be made or manufactured in India, are got from England, for which gold has to be paid, or its equivalent value in silver. Formerly, 10 rupees would buy a sovereign's worth of goods, now it takes 15 or 50 per cent. more. This loss in exchange is a very

serious one to the Government, and for the colliery and railway together, it has been, since the colliery commenced, 169,484 rupees or £11,298 at present rate of exchange, or £16,948 at par.

## THE COST OF WORKING.

This is shown in detail as follows for two half-years. In the first half of a calendar year there are four busy months, and for that half-year the cost of production is smaller than that of the second half-year, when two busy months only are included.

The cost is given for the last two completed half-years, when the author left India, *i.e.*, half-year ending December 31, 1887, and half-year ending June 30, 1888. There is also added the estimated cost of working during the half-year ending December 31, 1888, which is, however, not of much importance, for there exists generally a very considerable difference between estimated cost and actual cost, even in Government concerns.

| | Half-year ending 31st December, 1887, 44,111 tons. Cost per ton in annas or pence. | Half-year ending 30th June, 1888, 68,290 tons. Cost per ton in annas or pence. | Half-year ending 31st December, 1888, 65,946 tons. Estimated cost of above quantity in annas or pence. |
|---|---|---|---|
| (1) *General Superintendence.* | | | |
| Engineer's salary ... ... ... | 2·88 | 2·24 | 2·51 |
| Do. allowances ... ... ... | ·04 | ·01 | ·29 |
| Subordinate superintendence ... ... | 3·21 | 2·15 | 2·61 |
| Do. allowances ... ... | ·02 | ·02 | ·01 |
| Office expenses ... ... ... ... | ·67 | ·56 | ·53 |
| (2) *Working Expenses.* | | | |
| Coal cutting—Wages ... ... ... | 11·57 | 10·97 | 11·61 |
| Materials ... ... | 1·63 | 1·71 | |
| Raising and underground haulage— | | | |
| Wages ... ... ... ... ... | 6·04 | 5·99 | 5·73 |
| Materials ... ... ... ... | ·47 | ·45 | |
| Winding engine expenses—Wages ... | ·61 | ·48 | 1·44 |
| Coal ... | ·58 | ·56 | |
| Other stores | ·44 | ·39 | |
| Pumping engines and pumps— | | | |
| Wages ... ... ... ... ... | 3·93 | 1·83 | 9·38 |
| Coal ... ... ... ... ... | 10·16 | 3·85 | |
| Other stores ... ... ... ... | ·69 | ·33 | |
| Shunting engine expenses—Wages ... | ·24 | ·10 | ·36 |
| Coal ... | ·09 | ·19 | |
| Other stores | ·08 | ·05 | |
| Surface lighting ... ... ... ... | ·24 | ·20 | ·21 |
| (3) *Repairs and Renewals of Machinery.* | | | |
| Pumping engines, pumps, and boilers— | | | |
| Wages ... ... ... ... ... | 2·77 | 1·59 | 3·94 |
| Materials ... ... ... ... | 2·81 | 1·59 | |
| Winding engines, cages, &c.—Wages ... | 1·46 | 1·00 | 2·42 |
| Materials | 1·84 | ·70 | |
| Pit tubs—Wages ... ... ... | ·57 | ·36 | ·58 |
| Materials ... ... ... | ·37 | ·45 | |
| Shunting engines—Wages ... Materials ... | ·37 | ·03 | ·32 |
| (4) *Maintenance.* | | | |
| Shafts and workings—Wages ... ... | 2·67 | 2·11 | 4·07 |
| Materials ... | 2·52 | 2·21 | |
| Tramways—Wages ... ... ... | ·30 | ·15 | 1·71 |
| Materials ... ... ... | 1·92 | ·32 | |
| Ventilation—Wages ... ... ... | 1·22 | ·56 | 1·98 |
| Materials... ... ... | 1·18 | ·63 | |
| Trapper boys ... ... | ·27 | ·40 | |
| (5) *New Minor Works.* ... ... | ·17 | 3·02 | 2·18 |
| (6) *Unclassified Expenditure.* | | | |
| Tools and plant ... ... ... ... | ·77 | ·56 | ·56 |
| Loss on stores ... ... ... ... | ·06 | ·02 | ·05 |
| Other items—Underground fire principally ... ... ... ... ... | 2·50 | 1·50 | 1·98 |
| Carriage in revenue stores ... ... | ·14 | ·13 | ·12 |
| Dead work and putting through faults | ·03 | ·34 | ·03 |
| Sinking fund charges ... ... ... | 4·31 | 4·41 | 3·85 |
| | 71·84 | 54·16 | 58·47 |

From this it will be seen that the management, subordinate staff, and office expenses amount to 4·83, 3·13 and 4·06 pence per ton for the half-year ending 31st December, 1887, 30th June, 1888, 31st December, 1888, respectively. Pumping is a very heavy charge at Warora, far more than it should be, being 20·36, 9·19, and 13·32 pence per ton for the respective half-years. The underground fire charges vary from 2½d. to 1½d. per ton, and the sinking fund charges to 4·41 and 3·85 pence per ton highest and lowest during the last three half-years.

The foregoing table shows the total charges per ton for mining; and, as the coal cutting is let to contractors, this paper would be incomplete without giving some details as to the cost per ton paid by the contractors in raising the coal:—

Cost of Cutting and Raising Coal by Contractors in the Whole Mine.

| | Annas or pence per ton | |
|---|---|---|
| Coal cutting | 7·500 | |
| Oil and wick for ditto | ·946 | 8·446 |
| Cutting drains | ·076 | |
| Oil and wick for ditto | 009 | ·085 |
| Cutting faults and troubles as per agreement | ·015 | |
| Oil and wick for ditto | ·001 | ·016 |
| Tramming | 4·000 | |
| Baskets | ·072 | |
| Oil and wick for ditto | ·339 | 4·411 |
| Platelayers | ·142 | |
| Oil and wick | ·016 | ·158 |
| Mates | ·148 | |
| Oil and wick | ·015 | ·163 |
| Onsetters | ·247 | |
| Oil and wick | ·035 | ·282 |
| Tubmarkers (clerks who keep the tramming account) | ·112 | |
| Oil and wick | ·008 | ·120 |
| Banksmen, screenmen, women, and baskets | ·350 | |
| Oil and wick for night screenmen | ·014 | ·364 |
| Contractor's storekeeper | ·035 | |
| ,, store coolies | ·026 | ·061 |
| Clerks and stationery | ·129 | |
| Office, store rent, &c. | ·007 | ·136 |
| Cost of lighting pit bottom | ·054 | |
| Cost of whitewashing ditto | ·004 | ·058 |
| | | 14·300 |

| | Per ton. | Rup. As. |
|---|---|---|
| Contractors' earnings 78 % large coal, 22 % small ditto | | |
| Large coal at 1 rup. 4 as. and small coal at 12 as. per ton | | 1 2·240 |
| Deduction—Colliery consumption | 1·053 | ... |
| ,, ⅔ of winding engine staff | ·493 | ... |
| ,, Conservancy cess $\frac{1}{1\cdot2}$ penny per ton | ·083 | 1·629 |
| Net rate paid to contractor | | 1 0·611 |
| Cost of production | | 14·300 |
| Profit per ton | | 2·311 |

CUTTING AND RAISING COAL BY CONTRACTORS IN THE WHOLE MINE—*Continued.*

| | Annas or pence. | |
|---|---|---|
| It is proposed to deduct the following items from the contractor's earnings and give him an increased rate to meet the deductions :— | | |
| | Pence per ton. | |
| Shots ... ... ... ... ... ... | 1·108 | |
| Coolies (off-hand labour) and shotmen ... | 1·193 | |
| Additional ⅓ winding staff ... ... ... | ·024 | |
| All tools ... ... ... ... ... ... | ·348 | |
| | 2·853 | |
| Cost of other items ... ... ... ... | 14·300 | |
| Total cost of raising ... ... ... | 17·153 | |
| | Rup. As. | |
| Increased rate 1 rup. 8 as. large coal, 13 as. small | 1 5·579 | |
| Deductions ... ... ... ... ... ... | 1·629 | |
| | 1 3·950 | |
| Cost of getting as above ... ... ... ... | 1 1·153 | |
| Profit per ton ... ... ... ... ... ... | 2·797 | |

COST OF CUTTING AND RAISING COAL BY CONTRACTORS IN THE BROKEN MINE.

| | Annas or pence per ton. | |
|---|---|---|
| Cutting coal or hewing ... ... ... .. ... ... | 4·250 | |
| Oil and wick ditto ... ... ... ... ... ... | ·946 | 5·196 |
| Cutting drains ... ... ... ... ... ... ... | ·076 | |
| Oil and wick ... ... ... ... ... ... ... | ·009 | ·085 |
| Cutting faults, *nil* ... ... ... ... ... ... | ... | |
| Tramming .. ... ... ... ... ... ... ... | 3·750 | |
| Baskets ... ... ... ... ... ... ... ... | ·072 | |
| Oil and wick for ditto ... ... ... ... .. ... | ·339 | 4·161 |
| Platelayers ... ... ... ... ... ... .. | ·142 | |
| Oil and wick ... ... ... ... ... ... ... | ·016 | ·158 |
| Tubmarkers (clerks who keep tramming account) ... ... | ·112 | |
| Oil and wick ... ... ... ... ... ... ... | ·008 | ·120 |
| Onsetting ... ... ... ... ... ... ... ... | ·247 | |
| Oil and wick ... ... ... ... ... ... .. | ·035 | ·282 |
| Banksmen, screenmen, women, and baskets... ... ... | ·350 | |
| Oil and wick for night screenmen ... ... ... ... | ·014 | ·364 |
| Contractor's storekeeper ... ... ... ... ... | ·035 | |
| ,, store coolies ... ... ... ... ... | ·026 | ·061 |
| Clerks, stationery, &c. ... ... ... ... ... ... | ·129 | |
| Office, store rent, &c. ... ... ... ... ... ... | ·007 | ·136 |
| Lighting pit bottom ... ... ... ... ... ... | ·054 | |
| Whitewashing ditto ... ... ... ... ... ... | ·004 | ·058 |
| | 10·621 | 10·621 |

CUTTING AND RAISING COAL BY CONTRACTORS IN THE BROKEN MINE—*Continued.*

| | Annas or pence per ton. | |
|---|---|---|
| | | Annas. |
| Contractor's earnings, large 78 % at 13 as. a ton, small coal 22 % at 8 as. a ton, per ton .. . ... ... ... | ... | 11·900 |
| Deduction—Colliery consumption ... ... ... ·700 | | |
| ,, $\frac{2}{3}$ winding charges... ... ... .. ·493 | | |
| ,, Conservancy cess $\frac{1}{12}$ penny per ton ... ·083 | | |
| | | 1·276 |
| Net rate paid to contractor per ton ... ... ... ... | ... | 10·624 |
| Cost of production ... ... ... ... ... ... | ... | 10·621 |
| Profit ... ... .. ... ... ... ... ... | ... | 0·003 |
| It is proposed to deduct the following items from the contractor's earnings and give him an increased rate :— | | |
| Shots ... ... ... ... ... ... 0·923 | | |
| Coolies (off-hand labour) ... ... ... 1·193 | | |
| Additional $\frac{1}{3}$ winding staff ... ... ... ·204 | | |
| All tools ... ... ... ... ... ... ·348 | | |
| 2·668 | | |
| Add above deductions .. ... ... ... 1·276 | | |
| 3·944 | | |
| Increased rate 1 rup. 1 an. large coal, and 8 as. small coal = per ton for earnings ... ... Annas. 15·020 | | |
| Less deductions as above ... ... ... 3·944 | | |
| 11·076 | | |
| Cost of production ... ... ... ... 10·621 | | |
| Profit per ton ... ... ... ... ... ·455 | | |

The profit per ton on the broken coal is hardly sufficient even at the enhanced rates, and a further increase of rates will have to be offered as an inducement for contractors to take to working the broken mine.

## PRICE OF LABOUR.

| Description of Labour. | No. employed now. | No. of hours worked per day. | Wages per day. |
|---|---|---|---|
| WORKSHOP MEN. | | Per week. | Rup. As. |
| Shop Fitters ... ... ... ... | 1 | 56 | 1 4 |
| | 1 | ... | 1 8½ |
| | 1 | ... | 1 2 |
| | 2 | ... | 1 0 |
| | 3 | ... | 0 14 |
| | 2 | ... | 0 11 |
| | 2 | .. | 0 12 |
| | 2 | ... | 0 10 |
| | 14 | | |
| Apprentice Fitters .. .. ... | 1 | ... | 0 7 |
| | 1 | ... | 0 6 |
| | 1 | ... | 0 5 |
| | 1 | ... | 0 4 |
| | 1 | ... | 0 2½ |
| | 1 | ... | 0 2 |
| | 6 | | |
| Turners ... ... . ... .. | 1 | ... | 1 12¼ |
| | 1 | ... | 1 5 |
| | 1 | ... | 1 4 |
| | 1 | ... | 0 13 |
| | 1 | ... | 0 10 |
| | 5 | | |
| Apprentice turners ... ... ... | 1 | ... | 0 5 |
| | 1 | ... | 0 4 |
| | 2 | ... | 0 3 |
| | 4 | | |
| Machine men ... ... ... ... | 1 | ... | 0 8 |
| | 1 | ... | 0 7 |
| | 1 | ... | 0 6 |
| | 3 | ... | 0 5 |
| | 2 | ... | 0 4 |
| | 8 | | |
| Boilermakers .. ... ... ... | 1 | ... | 1 2 |
| | 1 | ... | 1 1 |
| | 2 | | |
| Rivetters' foreman .. ... ... | 1 | ... | 1 0 |
| | 1 | | |
| Rivetters ... ... ... ... ... | 1 | ... | 0 13 |
| | 1 | ... | 0 11 |
| | 1 | ... | 0 10 |
| | 5 | ... | 0 8 |
| | 2 | ... | 0 7 |
| | 1 | ... | 0 6 |
| | 11 | | |
| Rivet holders ... ... ... ... | 7 | ... | 0 6 |
| | 10 | ... | 0 5 |
| | 4 | ... | 0 3 |
| | 2 | ... | 0 2½ |
| | 3 | ... | 0 2 |
| | 1 | ... | 0 4 |
| | 27 | | |
| Painters ... ... ... ... .. | 1 | ... | 0 10 |
| | 1 | ... | 0 8 |
| | 2 | ... | 0 6 |
| | 4 | | |
| | 82 | | |

## PRICE OF LABOUR.

| Description of Labour. | | No. employed now. | No. of hours worked per day. | Wages per day. |
|---|---|---|---|---|
| WORKSHOP MEN—*continued.* | 82 | 82 | Per week. | Rup. As. |
| Pattern makers ... ... ... ... | 1 | 1 | 56 | 0 14 |
| Moulders ... ... ... ... ... | 1 | 1 | ... | 0 10 |
| | | 2 | ... | 0 5 |
| | | 1 | ... | 0 3 |
| | 4 | | | |
| Coppersmith ... ... ... ... | 1 | 1 | ... | 1 2 |
| Tinman ... ... ... ... ... | 1 | 1 | ... | 0 10 |
| | | 1 | ... | 0 7 |
| | 2 | | | |
| Chippers ... ... ... ... .. | | 1 | ... | 0 6 |
| | | 1 | ... | 0 5 |
| | | 2 | ... | 0 4 |
| | 4 | | | |
| Leatherman ... ... ... ... | 1 | 1 | ... | 0 6½ |
| Tool keeper ... ... ... .. | 1 | 1 | ... | 0 5 |
| Water man ... ... ... ... | | 1 | ... | 0 4 |
| | 2 | | | |
| Water woman ... ... ... ... | | 1 | ... | 0 4 |
| Coal woman ... ... ... ... | | 2 | ... | 0 1½ |
| | 3 | | | |
| | 1 | 1 | ... | 0 2 |
| Odd boys ... ... ... ... ... | | 2 | ... | 0 3 |
| | | 1 | ... | 0 2½ |
| | 3 | | | |
| Sweeper ... ... ... ... ... | 1 | 1 | ... | 0 4 |
| Engineman for shop engine ... ... | 1 | 1 | ... | 0 6 |
| Fireman ... ... ... ... ... | 1 | 1 | ... | 0 5 |
| Coal men carry coal ... ... ... | 2 | 2 | ... | 0 5 |
| Blacksmiths ... ... ... ... | | 1 | ... | 1 12 |
| | | 1 | ... | 1 9 |
| | | 1 | ... | 1 7 |
| | | 2 | ... | 1 6 |
| | | 1 | .. | 1 0 |
| | | 1 | ... | 0 14 |
| | | 1 | ... | 0 13 |
| | | 2 | .. | 0 10 |
| | | 2 | ... | 0 9 |
| | | 4 | ... | 0 8 |
| | | 3 | ... | 0 7 |
| | | 1 | ... | 0 6 |
| | 20 | | | |
| Strikers ... ... ... ... ... | | 13 | ... | 0 5 |
| | | 17 | ... | 0 4 |
| | | 1 | ... | 0 3 |
| | 31 | | | |
| | 160 | | | |

PRICE OF LABOUR.

| Description of Labour. | | No. employed now. | No. of hours worked per day. | Wages per day. |
|---|---|---|---|---|
| WORKSHOP MEN—*continued.* | 160 | 160 | per week | |
| Carpenters ... ... ... ... | | 7 | 56 | 0 14 |
| | | 2 | ... | 0 13 |
| | | 4 | ... | 0 12 |
| | | 1 | ... | 0 11 |
| | | 7 | ... | 0 10 |
| | | 2 | ... | 0 9 |
| | | 6 | ... | 0 8 |
| | | 4 | ... | 0 7 |
| | | 2 | ... | 0 6 |
| | 35 | | | |
| Sawyers ... ... ... ... ... | | 4 | ... | 0 5 |
| | | 1 | ... | 0 4 |
| | 5 | | | |
| Workmen's coolies (all carpenters have each a coolie to carry their tools) ... | | 36 | ... | 0 4 |
| | 36 | | | |
| Coolie foreman (mukadam) ... ... | | 1 | ... | 0 12 |
| | 1 | | | |
| Shopyard coolies... ... ... .. | | 1 | | 0 4½ |
| | | 19 | ... | 0 4 |
| | 20 | | | |
| Native foremen— | | | | |
| Head shopman ... ... ... | 1 | 1 | ... | 46 rup. per mensem |
| Turning shop foreman ... ... | 1 | 1 | ... | 53 ,, ,, |
| Blacksmith ,, ⅖ charged to colliery ... ... ... .. | 1 | 1 | ... | 60 ,, ,, |
| Carpenter ,, ... ... | 1 | 1 | ... | 50 ,, ,, |
| Masonry foreman ... ... ... | 1 | 1 | ... | 32 ,, ,, |
| Timekeepers, chief for shops and colliery | 1 | 1 | ... | 58 ,, ,, |
| Head timekeepers ,, ,, | 1 | 1 | ... | 22 ,, ,, |
| Workshop timekeeper ... ... .. | | 1 | ... | 17 ,, ,, |
| | | 1 | ... | 12 ,, ,, |
| | 2 | | | |
| Pit timekeepers ... ... ... ... | | 1 | ... | 17 ,, ,, |
| | | 1 | .. | 12 ,, ,, |
| | | 2 | ... | 10 ,, ,, |
| | 4 | | | |
| ,, ,, candidate ... ... | 1 | 1 | ... | 10 ,, ,, |
| Foreman fitter, Eurasian, ⅖ of salary charged to colliery ... ... .. | 1 | 1 | .. | 100 rupees. |
| Supervisor, ½ charged to colliery ... | 1 | 1 | ... | 200 ,, |
| Total in shops... ... ... | 273 | 273 | | |
| Sweepers—Head sweepers ... ... | | 2 | ... | 8 ,, |
| Sanitation clerk ... ... | | 1 | ... | 12 ,, |
| Sweepers ... ... ... ... ... | | 11 | ... | 7 ,, |
| ,, ... ... .. ... ... | | 2 | ... | 6½ ,, |
| ,, ... ... ... ... ... | | 3 | .. | 6 ,, |
| ,, ... ... ... ... | | 2 | ... | 5 ,, |
| ,, women .. ... ... | | 4 | .. | 4 ,, |
| ,, ,, ... ... ... | | 2 | ... | 3½ ,, |
| ,, ,, ... ... ... | 28 | 1 | ... | 3 ,, |
| Total on surface not in connection with colliery.. .. ... ... ... | 301 | 301 | | |

LABOUR EMPLOYED BY GOVERNMENT INCLUSIVE OF CONTRACTORS' LABOUR.

| DESCRIPTION OF LABOUR. | No. employed. | No. of hours worked per day. | Wages per day. |
|---|---|---|---|
| COLLIERY. | | | |
| Surfacemen— | | | |
| Pumping enginemen .. ... ... | 2 | 8 | 25 rup. per month. |
| Old men accustomed also to pit work ... | 1 | 8 | 20 ,, ,, |
| 10 rup. per month ordered to be standard wage in future ... .. ... | 6 | 8 | 10 ,, ,, |
| 6 pumping engines—Underground special pump enginemen ... ... ... ... | 3 | 8 | 4 as. a day. |
| Winding enginemen—3 winding engines ... | 9 | 6 | 12 rup. per month. |
| Firemen, chargemen—15 boilers of which 3 are generally off ... ... ... ... | 6 | 8 | 9½ ,, ,, |
| Firemen .. ... ... ... .. | 30 | 8 | 9 ,, ,, |
| Coal boys (men who bring coal near to boilers and cart ashes away) ... ... | 32 | 8 | 4 as. a day. |
| Oil boys who fetch stores ... ... ... | ... | ... | ... |
| Donkey enginemen ... ... ... ... | 6 | 8 | 4 as. a day. |
| Filter cleaners... ... ... ... ... | 4 | 8 | 3 ,, ,, |
| Cleaners ... ... ... .. ... | 3 | 8 | 3 ,, ,, |
| Fan enginemen—1 fan engine ... ... | 3 | 8 | 10 rup. per mensem |
| Fan firemen—2 boilers ... ... .. | 6 | 8 | 9 ,, ,, |
| Fan boiler coal boys ... ... ... ... | 3 | 8 | 4 as. a day. |
| Pump men—Men who execute repairs in the pumping shafts. All old men, used to the work and been on the job since the pit commenced. Liable to be called out at any time to work. | 1 | 12 | 20 rup. per mensem |
| | 1 | | 19 ,, ,, |
| | 1 | | 16 ,, ,, |
| | 1 | | 15 ,, ,, |
| | 1 | | 13 ,, ,, |
| | 1 | | 12 ,, ,, |
| Colliery fitters get what is called consolidated pay, *i.e.*, they get no overtime. They can be called to work at any time for repairs. Always work on Sundays. | 1 | 62 hours per week | 39 ,, ,, |
| | 2 | | 30 ,, ,, |
| | 2 | | 25 ,, ,, |
| | 1 | | 20 ,, ,, |
| | 1 | | 18 ,, ,, |
| | 1 | | 16 ,, ,, |
| Colliery fitters ... ... ... ... | 3 | ... | 8 as. a day. |
| Colliery surface coolies ... ... ... | 1 | ... | 5 ,, ,, |
| | 7 | ... | 4 ,, ,, |
| 3 only required when cleaning out boilers | 4 | ... | 3 ,, ,, |
| Bankmen ... ... ... ... 7 | 1 | | 4 ,, ,, |
| | 6 | | 5 ,, ,, |
| Total number employed on surface without taking into account masons, women, and coolies ... ... ... ... ... | 150 | | |
| Masons' coolies ... ... ... ... | 2 | 8 | 4 as. a day. |
| Women carrying materials into pit head ... These vary with the amount of masonry work on hand. | 12 | 8 | 1½ ,, ,, |
| 1 woman who cuts grass for horses ... | 1 | | 1½ ,, ,, |
| Total on surface .. ... ... | 165 | | |

LABOUR EMPLOYED BY GOVERNMENT EXCLUSIVE OF CONTRACTORS' LABOUR.

| DESCRIPTION OF LABOUR. | No. employed. | No. of hours worked per day. | Wages per day. |
|---|---|---|---|
| COLLIERY. | | | |
| Underground labour ... ... ... | 1 | 8 | 30 rup. per mensem |
| Mates ... ... ... ... ... | 2 | ... | 18 ,, ,, |
| | 1 | ... | 17 ,, ,, |
| | 8 | .. | 16 ,, ,, |
| | 1 | ... | 15 ,, ,, |
| | 3 | .. | 14 ,, ,, |
| | 2 | ... | 13 ,, ,, |
| | 1 | ... | 11½ ,, ,, |
| | 2 | ... | 11 ,, ,, |
| | 2 | ... | 10 ,, ,, |
| | 23 | | |
| Coolies—Head coolies ... ... ... | 3 | ... | 5½ as. per day |
| | 53 | ... | 5 ,, ,, |
| | 8 | ... | 4½ ,, ,, |
| | 64 | | |
| Shotmen ... .. ... ... ... | 6 | ... | 6 ,, ,, |
| | 4 | ... | 5½ ,, ,, |
| | 1 | ... | 5 ,, ,, |
| | 11 | | |
| Shot boys... .. ... ... ... | 6 | ... | 3½ ,, ,, |
| | 3 | ... | 3 ,, ,, |
| | 9 | | |
| Boys, including trappers ... .. | 7 | ... | 3½ ,, ,, |
| | 5 | ... | 3 ,, ,, |
| | 21 | ... | 2½ ,, ,, |
| | 3 | ... | 2 ,, ,, |
| | 36 | | |
| Horsekeepers ... ... ... ... | 1 | ... | 5 ,, ,, |
| | 1 | ... | 4½ ,, ,, |
| | 1 | ... | 4 ,, ,, |
| | 3 | | |
| Horse boys or drivers ... ... ... | 5 | ... | 3½ ,, ,, |
| | 5 | | |
| Mining engineer and assistant mining engineer's lamp boys ... ... ... | 2 | ... | 5 ,, ,, |
| | 1 | ... | 4½ ,, ,, |
| | 1 | ... | 4 ,, ,, |
| | 1 | ... | 3½ ,, ,, |
| | 5 | | |
| Masons ... ... ... ... ... | 23 | ... | 10 ,, ,, |
| | 23 | | |
| Masons' coolies ... ... ... ... | 27 | ... | 5 ,, ,, |
| | 27 | | |
| Onsetters ... ... ... ... ... | 1 | ... | 4 ,, ,, |
| | 3 | ... | 4½ ,, ,, |
| | 6 | ... | 5 ,, ,, |
| | 10 | | |
| | 216 | | |
| Sweepers' mate ... .. ... ... | 1 | 9 | 9 rup. per mensem |
| | 8 | ... | 6½ ,, ,, |
| | 2 | ... | 5 ,, ,, |
| | 1 | ... | 3 ,, ,, |
| | 12 | | |
| Total Government labour underground | 228 | | |

The foregoing statements of wages show that the wages paid to any class of labour vary very much, and varied far more before the colliery-men were reduced and paid at a more even rate. The reason of such variation is, that old and deserving men have, from time to time, had increments awarded them, while new men have had to commence on low wages. Also, some men have had their wages reduced through not being found competent, or for punishment. It is only within the last year that the writer, when in charge of the surface-establishment of the colliery, brought about an equalisation, and effected a saving of 500 rupees per mensem by discharging many useless men, reducing wages, and lengthening hours. As an instance, the firemen worked six hours a day only. In the underground establishment, a saving of 250 rupees was effected, partly by reducing the number of masons employed.

The number of enginemen, both winding and pumping, and firemen, is absurdly large for a colliery drawing only 140,000 tons a year, and that is accounted for by having so many winding pits—3, so many pumping engines—6, and the pits having to work 24 hours per day.

## THE AREA AND AMOUNT OF COAL AT WARORA.

The small portion of the Wardha Valley Coalfield, found at Warora, has been now defined. Its limits to the east, north, and west are known, and its extension to the south, which seems to reach to Chanda, some 28 miles, with, of course, interruptions, is the only direction open for future enterprise. It is, therefore, a narrow strip two-thirds of a mile broad, with a northern limit known, and having a southern extension of many miles. The area proved by boreholes, and drained by the present pits, amounts to 250 acres, which, up to the present, have yielded little short of a million tons, and which will no longer provide for the annual demand of 150,000 tons of coal. Of the drained area, 168 acres have been worked, leaving 82 acres to work. These 82 acres contain four million tons of coal, nearly, in the two seams together, of which 2½ millions should be got. Of the 168 acres already worked, nothing will be got of consequence from the No. 2 Seam, and 68 acres will be lost in No. 3 Seam through the fire, leaving only 100 acres of coal in No. 3 Seam worked in pillars, which will give one quarter of a million tons of coal to be won in the broken. On the whole, say three

million tons remain to be worked in the drained area in the two seams, from which one million may be deducted on account of No. 2 Seam thinning out much faster to the rise than No. 3 Seam, so that two millions of tons remain to be raised by the present pits, which, at 130,000 tons a year—no more per year can be got without more pits—would last 15 years. Another pit will be required to get the required output of 150,000 tons of coal, a demand which would increase to 200,000 tons per annum could it be raised easily. Should another pit be now sunk to the south—a shallow one to assist the present ones—150,000 tons could be raised in 1890.

Another area of 200 acres has been proved by boreholes, but lies to the dip of the present pits. This area should yield 5,500,000 tons in the two seams. A separate and complete new winning would be required to get this coal, consisting of two pits about 300 feet deep, with pumping and ventilating engines.

Summing up, it may be stated that 7½ million tons remain unworked in the proven area of about 450 acres, which will require more pits to get 150,000 tons per annum. In the present year, the output will not reach 150,000 tons to provide for the estimated demand. It would appear to a stranger that six pits should be amply sufficient for 150,000 tons a year, but the present number are all so close together, and four of these do not draw coal—No. 2 Pit is now idle for want of coal—so that the whole output falls on two pits. And, again, as the rate of opening out is so slow—15 feet a week—it may be imagined what a time it takes to get enough working faces for a large output, at the rate of half a ton per man.

The writer, from the very beginning of his career in India, drew the Government's attention to the inadequate means of getting at the coal. The Government were misled by a report (by a gentleman who is not a Mining Engineer according to the Act of 1871 or 1887, nor had had any English practice, save as an unsuccessful merchant, and who had charge of a little colliery in India) in which it was stated that the coal was sufficient to last for 147 years, including the coal in No. 1 Seam, which as a workable seam does not exist, and the same gentleman brought it down to 15 years in another report 1½ years ago. It may be broadly stated, that if 150,000 tons of coal could be raised, for which there is demand, the colliery would have a life of 50 years.

THE DISTRIBUTION OF WARORA COAL.

Last year 134,236½ tons of coal were raised, which found its way among customers as follows:—

| | Tons. | Per Cent. of Total. |
|---|---|---|
| Railways, Great Indian Peninsulars ... | 70,112 | 51·8 |
| „ Bengal-Nagpore... ... ... | 23,620 | 17·4 |
| „ Wardha Coal State ... ... | 3,692½ | 2·7 |
| Total railways ... ... ... | 97,424½ | 71·9 |
| Cotton Mills, Empress Mill, Nagpore ... | 3,530 | 2·6 |
| „ Budnera Mill Co. ... | 11,272 | 8·3 |
| „ Hinganghat Mill Co. ... | 5,820 | 4·3 |
| Total mills ... ... ... | 20,622 | 15·2 |
| Colliery consumption ... ... ... | 13,410 | 9·9 |
| Other customers ... ... ... ... | 4,030 | 3·0 |
| Total ... ... ... ... | 135,486½ | 100·0 |
| Less stock ... ... ... ... ... | 1,250 | —— |
| Net output ... ... ... ... ... | 134,236½ | |
| This year's estimated demand is as under:— | | |
| Railways, Great Indian Peninsular ... ... | 72,000 | 48·0 |
| „ Bengal-Nagpore ... ... ... | 34.400 | 22·9 |
| „ Wardha Coal State ... ... | 3,900 | 2·6 |
| Total railways ... ... ... | 110,300 | 73·5 |
| Cotton Mills, Empress Mill, Nagpore<br>„ Budnera Mill Co. ...<br>„ Hinganghat Mill Co. } ... | 16,300 | 10·9 |
| Colliery consumption ... ... ... | 14,900 | 9·9 |
| Other customers .. ... ... ... | 8,500 | 5·7 |
| Total ... ... ... ... | 150,000 | 100·0 |

Were this amount required in equal monthly quantities, the raising of the coal would not be a great difficulty, but as the coal cannot be stacked and must be freshly mined, the difficulty is great. Stacking over steam, as advised by the author, has yet to be tried.

The following statement shows the output per month during last year. Another difficulty exists during the rains, when fewer men come to work, the heavy showers preventing the rest:—

| | | |
|---|---|---|
| January... ... ... ... ... | 14,450 | tons. |
| February ... ... ... ... | 12,300 | „ |
| March ... ... ... ... ... | 12,630 | „ |
| April ... ... ... ... ... | 10,470 | „ |
| May ... ... ... ... ... | 9,710 | „ |
| June ... ... ... ... ... | 8,730 | „ |
| July ... ... ... ... ... | 9,342½ | „ |
| August ... ... ... ... ... | 9,901 | „ |
| September ... ... ... ... | 8,406 | „ |
| October... ... ... ... ... | 10,778 | „ |
| November ... ... ... ... | 14,419 | „ |
| December ... ... ... ... | 13,100 | „ |
| Total ... ... | 134,236½ | |

Warora coal is used for freight trains on the Great Indian Peninsular Railway from—

| | |
|---|---|
| Wardha east to Nagpore a distance of ... | 48 miles |
| West to Nandgaon ... ... ... ... | 294 „ |
| East of Bosawul on the Jubbulpur line to Hurda | 141 „ |
| Total distance on Great Indian Peninsular Railway, on which Warora coal is burnt ... | 483 „ |
| On Bengal-Nagpore Railway— | |
| From Nagpore eastward ... ... ... | 146 „ |
| Wardha Coal State Railway ... ... ... | 45 „ |
| Total ... ... ... | 674 |

The Bengal-Nagpore Railway is under construction, only 146 miles are open, and 474 miles remain still to be laid. But when this railway is finished, Raniganj coal will compete with Warora, in the far east where the Bengal-Nagpore join the East India at Assensole, where coal is obtained at 3 rupees per ton, while Warora coal at Nagpore costs 6 rupees 10 annas 10½ pies per ton. Again competition will arise also from Umaria Colliery, which lies on a branch of the Bengal-Nagpore Railway. This branch line will be 180 miles long, and join the Bengal-Nagpore main line at Bilaspur, about 200 miles east of Nagpore. Should also the Wardha Coal State Railway be pushed on to Chanda and Warangal, in the Nizam's dominions, a fresh demand would be created, and Warora coal would be used until it met Singareni coal from the south.

## FUEL CONSUMPTION AND SUPPLY ON INDIAN RAILWAYS.

*From the Indian Railways Administration Reports for 1887.*

| | Coal. | | | | |
|---|---|---|---|---|---|
| | English. Tons. | Indian. Tons. | Coke. Tons. | Patent Fuel. Tons. | Wood. Tons. |
| 1887 ... | 212,529 ... | 479,210 ... | 9,564 ... | 30,029 ... | 292,808 |
| 1886 ... | 240,063 ... | 460,948 ... | 9,132 ... | 26,219 ... | 259,513 |

The average cost per ton of fuel on some of the principal lines is given as under for 1887 :—

See Plate II.

| Railway. | Gauge. Ft. | In. | Length. Miles. | Fuel consumed. | Average cost per ton. Rupees. | Source and description of fuel used. |
|---|---|---|---|---|---|---|
| East India ... ... | 5 | 6 | 1,513 | 193,376 | 2·18 | Bengal coal. |
| Rajputana-Malwa ... | 3 | 3⅜ | 1,667 | 66,576 | 20·24 | English & Bengal, principally latter |
| Great Indian Peninsular | 5 | 6 | 1,288 | 199,142 | 11·07 | English, Warora, Mohpani, and Bengal coal and wood, but principally English coal. |
| Mysore ... ... ... | 3 | 3⅜ | 140 | 7,499 | 5·57 | Wood. |
| Bengal-Nagpore .. ... | 3 | 3⅜ | 149 | 11,494 | 6·63 | Warora coal. |
| Wardha coal ... ... | 5 | 6 | 45 | 3,156 | 3·83 | Warora coal. |
| Madras ... ... ... | 5 | 6 | 839 | 111,417 | 5·12 | Wood and patent fuel, principally the former. |
| Bhavnagar-Gondal ... | 3 | 3⅜ | 193 | 2,858 | 19·66 | Welsh coal. |
| Burma ... ... ... | 3 | 3⅜ | 333 | 10,237 | 21·55 | English patent fuel, and wood. |
| Jodhpore ... ... ... | 3 | 3⅜ | 124 | 1,215 | 31·24 | Bengal coal. |
| Nizam's ... ... ... | 5 | 6 | 274 | 27,853 | 4·48 | Wood. |
| North Western ... ... | 5 | 6 | 2,386 | 123,673 | 13·84 | Bengal and Salt range coal, patent fuel, and wood. |
| Katni-Umaria ... ... | 5 | 6 | 37 | 907 | 5·71 | Umaria coal. |
| Bombay, Baroda, and Central India ... ... | 5 | 6 | 439 | 37,367 | 14·92 | English coal, and wood (a very small percentage of the latter). |

## OTHER COLLIERIES IN INDIA.

The East-Indian Railway Company's Colliery produced, during 1887, 280,219 tons, of which 174,724 were supplied to their own railway at a net cost of 2 rupees 4 annas, for the first part of 1887, and 2 rupees 8 annas per ton, for the second half.

In the Central Provinces, a coalfield was recently explored by the Geological Survey, called the Rampore Coalfield, but in exploration it has been proved that the coal as fuel is valueless. The Bengal-Nagpore Railway passes near this coalfield.

Coal is being quarried at Cherra Poonjee, in the North-Eastern Provinces of India, in the Khasia State. Only 157 tons of this coal were consumed on the Cherra Company's Ganj Railway in 1887, at a cost of 13·64 rupees per ton.

The Makum Coalfields have proved exceedingly valuable ; they are leased to the Assam Railway and Trading Company, and the coal is sold at Calcutta for 14 rupees a ton. The output in 1886 reached 71,918 tons.

In Upper Burma, coal has been found in the Kali Valley, on the Hinduri. A seam 10 feet thick has been discovered which dips at 45 degs. It had not been worked in the beginning of 1888.

Umaria Colliery, in the Central Provinces, raised 25,548 tons in 1887. The cost of the coal delivered into wagons at this colliery was 4·27 rupees per ton in 1887, against 10·51 rupees in 1886.

Dandot Colliery, in the Salt Range of the Punjaub, has one seam 2 feet thick. 13,300 tons were raised in 1887, and the prices varied from 6 rupees 8 annas to 9 rupees 8 annas a ton. A new winning is being made, but a seam with only 2 feet of coal can hardly be looked upon as being of any value except for very small quantities of coal.

Coal has been found at the Khost Range, in Afghanistan, on the Sind-Pishin Railway, where two seams, one of 10 inches and one of 16½ inches have been discovered. The dip is from 25 degs. to 50 degs. These thin seams, however, are worthless for large outputs, and their value is, therefore, but limited.

Coal in the Nizam's dominions is actively being worked at Singareni, where is collected the finest colliery machinery to be seen in India, and where coal-heading machines of the Stanley patent are being used to get over the difficulty of the slow working of the Indian hewers. It is hoped that these machines will be able to open out a mine very quickly, thus providing many faces

to ensure a large output. The colliery is expected to raise 1,000 tons a day. The coal is good, superior to Warora; a large demand exists for this coal on South Indian Railways.

The petroleum wells at Khatun, near Sibi, in Beluchistan, have not proved of that value which was expected of them. The oil is too viscid to run in pipes. Nothing has as yet been done but putting down boreholes; no railway yet runs to the seat of operations.

Mohpani Colliery collapsed in 1883 by a great subsidence of the strata, but under active and experienced management, which it has now got, and which it very much needed, great improvement as to quantity and cost of coal has taken place.

The average cost of English coal at Bombay during 1884 was 17 rupees 2 annas 6 pies per ton. Raniganj coal cost 3 rupees at the pit's mouth. In 1883, English coal at Bombay averaged 16 rupees per ton.

As to the total annual output of Indian coal, no reliable statistics exist; this does not say much for the Statistical Department of the Indian Government, who, in other and minor matters, are bureaucratic to a fault. In great contrast are the railway statistics compiled annually, replete with every information. An Indian Mines Regulation Act would, in this respect, seem highly necessary. The Geological Survey Department of India gives for 1885 an output of 1,294,221 tons, and for 1886, 1,388,487 tons, from 105 collieries employing 24,794 men.

The Administration Report on the Railways in India, for 1881-82, gives some very interesting information regarding the extent of use of Indian and English Coals, and from it the following information is taken:—

"The Eastern Bengal Railway obtained Raniganj coal at 8 rupees 15 annas 6 pies and 7 rupees 11 annas 6 pies per ton, 125 miles from the collieries at Shamnagar Station.

The Oude and Rohilkund used Bengal coal at 3 rupees 4 annas per ton at the mine, the coal costing at Benares, 316 miles from the mine, 12 rupees per ton.

The Sind, Panjab and Delhi Railways used Bengal coal, which costs at Ghaziabad, 782 miles from the mines, 21 rupees 8 annas 2 pies per ton.

Wood is burnt costing 25 rupees per 100 maunds, and English coal at Kurachi costs 17 rupees per ton.

The Great Indian Peninsular Railway used English coal at 17

rupees 6 annas 11 pies at Bombay, from Bombay to Nandgaon, where it meets Warora coal.

The Bombay, Baroda, and Central India Railway used English coal at 14 rupees 12 annas 6 pies, at Bombay.

The Madras Railway used patent fuel, cost, landed at Madras, 18 rupees a ton; wood also used at 3 rupees 6 annas to 8 rupees per ton, average rate 5 rupees. Relative value of patent fuel and wood are as 1 to 3.

South Indian Railways used English coal and wood. English coal averages, when first received on the railway, 16 rupees 2 annas per ton; wood costs 4 rupees 8 annas per ton.

The Northern Bengal used Bengal coal which, at the colliery, cost 4 rupees 4 annas, and on the railway 11 rupees 12 annas and 12 rupees 5 annas.

The Indian Valley Railway (now part of North-Western) used English coal which, at Kurachi, cost 19 rupees 2 annas 6 pies; wood is also used.

The Nizam's Railway used, in 1882, only wood. Mohpani coal, at the pit's mouth, costs 9 rupees per ton, and only a very limited output is obtained, its maximum output being 30,000 tons in one year.

The prices of English coal were as follows:—

| | R. | A. | P. |
|---|---|---|---|
| Great Indian Peninsular, delivered at Bombay ... | 17 | 6 | 11 |
| Bombay, Baroda, and Central India do. ... ... | 14 | 12 | 6 |
| Rajputana-Malwa Railway do. ... ... | 14 | 11 | 0 |
| Sind, Panjab and Delhi Railway, delivered at Kurachi | 17 | 0 | 0 |
| Indian Valley Railway do. do. | 17 | 4 | 0 |
| Madras Railway, delivered at Madras (Patent Fuel) ... | 18 | 0 | 0 |
| South Indian do. do. ... ... ... | 16 | 2 | 0" |

Value of Indian Coals in

| | 1882. R. | A. | P. | 1889. R. | A. | P. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bengal Coal, per ton ... | 3 | 8 | 0 | 3 | 0 | 0 | | | | |
| Warora do. ... ... | 5 | 0 | 0 | 4 | 4 | 0 | to | 4 | 8 | 0 |
| Mohpani do. ... ... | 9 | 0 | 0 | 9 | 0 | 0 | | | | |
| Rewah (Umaria) estimated... | 5 | 0 | 0 | 4 | 2 | 7 | | | | |
| Singareni do. ... | 5 | 0 | 0 | 5 | 0 | 0 | | | | |

"A fair approximation of the relative values of the different kinds of coal available for use on Indian Railways is given as follows:—

| | |
|---|---|
| English ... ... ... ... ... | } 1,000 |
| Do. Patent Fuel ... ... ... | |
| Bengal Kurhurbaree ... ... ... | |
| Bengal Barakar ... ... ... ... ... | 870 |
| Rewah Umaria ... ... ... ... ... | 800 |
| Mohpani ... ... ... ... ... ... | 720 |
| Warora ... ... ... ... ... ... | 700 |
| Singareni ... ... ... ... ... ... | 700 |
| Wood ... ... ... ... ... ... | 330" |

At present (1889), the author thinks that in the above table, Kurhurbaree is over-rated, it should stand at 900. Umaria coal is also much over-estimated, being equal to Warora at 700; also, Mohpani should be 700, while Singareni should stand higher, say 800.

## TABLE SHOWING DISTRIBUTION OF COAL ON INDIAN RAILWAYS.

*From the India Railways Administration Report for 1882.*

| Railway and Section, omitting minor branches. | Miles. | Cost per ton of fuel at source of supply. | Source of supply of fuel. | Cost per ton of fuel at point where first received on line. | Freight charge per ton to centre of section. | Handling &c., per ton. | Total cost per ton at centre of section. |
|---|---|---|---|---|---|---|---|
| | | R A. P. | | R A. P. | R A. P. | R A. P. | R A. P. |
| East Indian— | | | | | | | |
| Howrah to Muddapur ... | 183 | 1 13 5 | Assensol. | 1 13 5 | 0 15 4 | 0 1 3 | 2 14 0 |
| Loop Line .. ... | 188 | 1 13 5 | Sitarampur. | 1 13 5 | 1 9 2 | 0 1 3 | 3 7 10 |
| Muddapur—Allahabad | 382 | 2 1 2 | Kurhurbaree. | 2 1 2 | 2 3 8 | 0 1 3 | 4 6 1 |
| Allahabad—Delhi ... | 390 | 2 1 2 | ,, | 2 1 2 | 6 4 0 | 0 1 3 | 8 6 5 |
| Allahabad—Jubbulpur | 228 | 2 1 2 | ,, | 2 1 2 | 5 6 6 | 0 1 3 | 7 8 11 |
| Eastern Bengal Railway | 152 | ... | Barakur. | 8 2 0 | 1 9 4 | 0 3 6 | 9 14 10 |
| Oudh and Rohilkund Railway ... ... ... | 547 | 3 4 0 | Kurhurbaree. | 12 0 0 | 6 6 9 | 0 4 10 | 18 11 7 |
| Sind, Panjab and Delhi Railway— | | | | | | | |
| Delhi—Lahore ... ... | 349 | 3 0 0 | Kurhurbaree. | 21 8 2 | 4 1 8 | 0 4 0 | 25 13 10 |
| Lahore—Mooltan ... | 208 | 6 12 0 | Wood. | 6 12 0 | 1 6 6 | 0 6 0 | 8 8 6 |
| Kurachi—Kotri ... | 105 | 17 0 0 | English. | 17 0 0 | 1 3 8 | 0 4 0 | 18 7 8 |
| Great Indian Peninsular— | | | | | | | |
| Bombay—Poona... ... | 119 | 17 6 11 | English. | 17 6 11 | 1 4 0 | 0 3 6 | 18 14 5 |
| Poona—Sholapur ... | 164 | 17 6 11 | ,, | 17 6 11 | 4 3 0 | 0 3 6 | 21 13 5 |
| Sholapur—Raichur ... | 160 | 17 6 11 | ,, | 17 6 11 | 7 9 0 | 0 3 6 | 25 3 5 |
| Bombay—Nandgaon ... | 178 | 17 6 11 | ,, | 17 6 11 | 1 13 8 | 0 3 6 | 19 8 1 |
| Dhond—Manmad ... | 145 | 17 6 11 | ,, | 17 6 11 | 4 14 4 | 0 3 6 | 22 8 9 |
| Nandgaon—Khandwa ... | 98 | 4 4 0 | Warora. | 5 11 6 | 6 6 7 | 0 3 0 | 12 0 1 |
| Bhusawal—Nagpur ... | 244 | 4 4 0 | ,, | 5 11 6 | 3 2 10 | 0 3 0 | 9 1 4 |
| Khandwa—Sohagpur ... | 141 | 9 0 0 | Mohpani. | 9 0 0 | 1 13 7 | 0 3 0 | 11 0 7 |
| Sohagpur—Jubbulpur ... | 121 | 3 12 0 | Kurhurbaree. | 18 7 0 | 1 9 5 | 0 3 0 | 20 3 5 |
| Bombay. Baroda, and Central India— | | | | | | | |
| Bombay—Ahmedabad ... | 309 | 14 12 6 | English. | 14 12 6 | 2 13 3 | 0 6 0 | 17 15 9 |
| Ahmedabad—Wadhwan | 80 | 14 12 6 | ,, | 14 12 6 | 6 5 10 | 0 6 0 | 21 8 4 |
| Gaekwar's Railway ... | 60 | 14 12 6 | ,, | 14 12 6 | 4 11 6 | 0 6 0 | 19 14 0 |
| Patri Salt Branch ... | 22 | 14 12 6 | ,, | 14 12 6 | 6 9 3 | 0 6 0 | 21 11 9 |

TABLE SHOWING DISTRIBUTION OF COAL ON INDIAN RAILWAYS.—*Continued.*

| Railway and Section, omitting minor branches. | Miles. | Cost per ton of fuel at source of supply. | | | Source of supply of fuel. | Cost per ton of fuel at point where first received on line. | | | Freight charge per ton to centre of section. | | | Handling &c., per ton. | | | Total cost per ton at centre of section. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R. | A. | P. | | R. | A. | P. | R. | A. | P. | R. | A. | P. | R. | A. | P. |
| Madras Railway— | | | | | | | | | | | | | | | | | |
| Madras—Jalarpet ... | 132 | 18 | 0 | 0 | Patent fuel. | 18 | 0 | 0 | 1 | 3 | 3 | 0 | 1 | 5 | 16 | 4 | 8 |
| Arkonam—Tirupati ... | 42 | 18 | 0 | 0 | ,, | 18 | 0 | 0 | 1 | 2 | 5 | 0 | 1 | 5 | 19 | 3 | 10 |
| Guntakul—Bellary ... | 32 | 18 | 0 | 0 | ,, | 18 | 0 | 0 | 5 | 4 | 4 | 0 | 1 | 5 | 23 | 5 | 9 |
| Jalarpet—Beypur ... | 274 | 5 | 0 | 0 | Wood. | 5 | 0 | 0 | 0 | 14 | 7 | 0 | 1 | 10 | 6 | 0 | 5 |
| Jalarpet—Bangalore ... | 85 | 5 | 0 | 0 | ,, | 5 | 0 | 0 | 0 | 8 | 9 | 0 | 1 | 10 | 5 | 10 | 5 |
| Tirupati—Raichur ... | 266 | 7 | 8 | 0 | ,, | 7 | 8 | 0 | 1 | 1 | 6 | 0 | 1 | 10 | 8 | 11 | 4 |
| South Indian— | | | | | | | | | | | | | | | | | |
| Madras—Tanjore ... | 290 | 15 | 2 | 0 | English. | 15 | 2 | 0 | 1 | 10 | 8 | 0 | 3 | 0 | 16 | 15 | 8 |
| Negapatam—Erode ... | 166 | 15 | 2 | 0 | ,, | 15 | 2 | 0 | 1 | 11 | 8 | 0 | 3 | 0 | 17 | 0 | 8 |
| Trichinopoly—Tuticorin | 195 | 15 | 2 | 0 | ,, | 15 | 2 | 0 | 2 | 0 | 8 | 0 | 3 | 0 | 17 | 5 | 8 |
| Northern Bengal Railway | 233 | 4 | 4 | 0 | Barakur. | 11 | 12 | 0 | 3 | 15 | 7 | 0 | 3 | 0 | 15 | 14 | 7 |
| Patria Gya Railway ... | 57 | 3 | 12 | 0 | Kurhurbaree. | 10 | 13 | 3 | 0 | 13 | 6 | 0 | 8 | 0 | 12 | 2 | 9 |
| Trihoot Railway ... | 75 | 3 | 12 | 0 | ,, | 9 | 8 | 0 | 1 | 1 | 9 | 2 | 3 | 0 | 12 | 12 | 9 |
| Cawnpore—Farukhabad Railway ... ... | 87 | 3 | 8 | 0 | ,, | 16 | 0 | 0 | 1 | 1 | 6 | 0 | 4 | 0 | 17 | 5 | 6 |
| Mnttra—Hathras Railway ... ... ... | 29 | 3 | 8 | 0 | ,, | 20 | 2 | 0 | 0 | 6 | 6 | 0 | 4 | 0 | 20 | 12 | 6 |
| Rajputana—Malwa Railway— | | | | | | | | | | | | | | | | | |
| Sabarnati—Nana ... | 149 | 14 | 11 | 0 | English. | 21 | 8 | 2 | 1 | 9 | 6 | 0 | 3 | 0 | 23 | 4 | 8 |
| Khandwa—Rutlam ... | 160 | 14 | 11 | 0 | ,, | 23 | 8 | 0 | 1 | 11 | 2 | 0 | 3 | 0 | 25 | 6 | 2 |
| Agra—Ajmere ... ... | 233 | 3 | 7 | 4 | Kurhurbaree. | 20 | 0 | 10 | 2 | 7 | 9 | 0 | 3 | 0 | 22 | 11 | 7 |
| Delhi—Bandekui ... | 136 | 3 | 7 | 4 | ,, | 22 | 7 | 4 | 1 | 7 | 1 | 0 | 3 | 0 | 23 | 1 | 5 |
| Ajmere—Nana ... ... | 152 | 3 | 7 | 4 | ,, | 20 | 0 | 10 | 6 | 9 | 1 | 0 | 3 | 0 | 26 | 12 | 11 |
| Ajmere—Rutlam ... | 233 | 3 | 7 | 4 | ,, | 20 | 0 | 10 | 7 | 7 | 0 | 0 | 3 | 0 | 27 | 10 | 10 |
| Jodhpur Railway ... | 17 | 3 | 7 | 4 | ,, | 20 | 0 | 10 | 7 | 1 | 11 | 0 | 3 | 0 | 27 | 5 | 9 |
| Panjab Northern Railway | | | | | | | | | | | | | | | | | |
| Lahore—Rawalpindi ... | 174 | 3 | 8 | 0 | ,, | 30 | 11 | 9 | 2 | 0 | 11 | 0 | 3 | 0 | 32 | 15 | 8 |
| Pindi—Peshawur ... | 105 | 3 | 8 | 0 | ,, | 30 | 11 | 9 | 5 | 5 | 11 | 0 | 3 | 0 | 36 | 4 | 8 |
| Turnool—Khushalgarh | 67 | 3 | 8 | 0 | ,, | 30 | 11 | 9 | 5 | 2 | 6 | 0 | 3 | 0 | 36 | 1 | 3 |
| Lala Musa—Bhera ... | 59 | 10 | 0 | 0 | Wood. | 10 | 0 | 0 | 0 | 13 | 7 | 0 | 7 | 0 | 11 | 4 | 7 |
| Indus Valley Railway— | | | | | | | | | | | | | | | | | |
| Mooltan—Rohri ... ... | 280 | 6 | 14 | 0 | ,, | 6 | 14 | 0 | 2 | 4 | 3 | 0 | 8 | 0 | 9 | 10 | 3 |
| Sukkur—Kotri ... ... | 227 | 4 | 10 | 0 | ,, | 4 | 10 | 0 | 1 | 11 | 2 | 0 | 8 | 0 | 6 | 13 | 2 |
| Ruk—Jacobabad ... | 37 | 4 | 10 | 0 | ,, | 4 | 10 | 0 | 0 | 8 | 2 | 0 | 8 | 0 | 5 | 0 | 2 |
| Jacobabad—Rindli ... | 112 | 17 | 4 | 0 | English. | 19 | 12 | 6 | 7 | 2 | 7 | 0 | 11 | 0 | 27 | 10 | 1 |
| Bhavnagar—Gondal Railway— | | | | | | | | | | | | | | | | | |
| Bhavnagar—Wadhwan | 106 | 21 | 0 | 0 | ,, | 21 | 0 | 0 | 1 | 2 | 0 | 0 | 5 | 0 | 22 | 7 | 0 |
| Dhola—Dhoraji ... ... | 88 | 21 | 0 | 0 | ,, | 21 | 0 | 0 | 1 | 9 | 6 | 0 | 5 | 0 | 22 | 14 | 6 |
| Nizam's Railway ... | 121 | 4 | 8 | 0 | Wood. | 4 | 8 | 0 | 0 | 7 | 6 | 0 | 3 | 0 | 5 | 2 | 6 |
| Burma Railway ... ... | 163 | 18 | 8 | 0 | English coal, now principally East Indian coal from Raniganj. | 18 | 8 | 0 | 2 | 9 | 0 | 0 | 8 | 0 | 21 | 9 | 6 |

## COST AT WARORA OF SOME OF THE MORE IMPORTANT STORES.

| | R. | A. | P. |
|---|---|---|---|
| Pit rails, 18 feet long, 20 lb., flat-bottomed section, steel, cost at Warora, per ton ... ... ... | 117 | 11 | 9 |
| Charcoal, small, for smithy purposes, per 100 cubic feet | 12 | 0 | 0 |
| „ large ditto ditto ... | 12 | 0 | 0 |
| English coke, for foundry, per ton ... ... ... | 49 | 0 | 0 |
| Bengal coke, from Giridi, per ton ... ... ... | 42 | 0 | 0 |
| English smithy coal, per ton ... ... ... ... | 36 | 1 | 8 |

COST AT WARORA OF SOME OF THE MORE IMPORTANT STORES.—*Continued.*

| | R. | A. | P. |
|---|---|---|---|
| Bengal smithy coal, per ton ... ... ... ... | 32 | 10 | 9½ |
| Cast iron pump pipes, cast in Bombay, per cwt. ... ... ... ... 6 12 0 to | 8 | 0 | 0 |
| Pick handles (English), with shoes for Hardy picks, 2 feet 6 inches long, each ... ... ... ... | 0 | 9 | 6 |
| Ditto without shoes, each ... ... | 0 | 8 | 0 |
| Hardy coal picks, 2½ to 3 lbs., each ... ... ... | 0 | 14 | 9 |
| Shoes for Hardy picks, each ... ... ... ... | 0 | 5 | 9 |
| Sleepers (teak), for pit, large, each ... ... ... | 0 | 15 | 0 |
| „ „ small, each ... ... ... | 0 | 8 | 0 |
| Tram horses' food, per cwt. ... ... ... ... | 3 | 10 | 0 |
| Coal tar, per cwt. ... ... ... ... ... | 6 | 4 | 0 |
| Brass ingot, per cwt. ... ... ... ... ... | 33 | 0 | 0 |
| Copper ingot, per cwt.... ... ... ... ... | 23 | 4 | 0 |
| Pig lead, per cwt. ... ... ... ... ... | 12 | 4 | 0 |
| Sheet lead, per cwt. ... ... ... ... ... | 19 | 0 | 0 |
| Iron sheets, plain galvanised, per cwt. ... ... | 11 | 8 | 0 |
| „ corrugated, per cwt. ... ... ... | 13 | 6 | 0 |
| Iron bars, of sizes, per cwt. ... ... ... ... | 6 | 8 | 0 |
| „ „ round Lowmoor, per cwt. ... ... ... | 16 | 1 | 0 |
| „ plates, common, per cwt., from ... 5 8 0 to | 7 | 12 | 0 |
| „ „ Lowmoor, per cwt., from ... 20 0 0 „ | 26 | 0 | 0 |
| Iron castings at Warora, per cwt., from 6 8 0 „ | 8 | 8 | 0 |
| Pig iron, per cwt. .. ... ... ... ... | 3 | 8 | 0 |
| Lang's patent plough steel winding ropes, 2¼ inches, per cwt. ... ... ... ... ... ... | 47 | 7 | 6 |
| Steel square, per cwt., from ... ... 26 4 0 to | 28 | 0 | 0 |
| Steel tool, per cwt., from ... ... 23 0 0 „ | 28 | 8 | 0 |
| Tin block, per cwt. ... ... ... ... ... | 101 | 0 | 0 |
| Zinc ingot ... ... ... ... ... ... | 14 | 12 | 6 |
| Teak wood, in logs, per cubic foot ... ... ... | 3 | 4 | 0 |
| Firebricks at Warora, per 100 ... ... ... | 19 | 7 | 0 |
| „ at Bombay, „ ... ... ... | 8 | 6 | 0 |
| English leather, per lb. ... ... ... ... | 1 | 12 | 0 |
| Wrought iron, per cwt. ... ... ... ... | 18 | 0 | 0 |
| Pit sleepers, teak, 3 feet by 5 inches by 3 inches, each | 0 | 8 | 0 |
| „ „ joint, 3½ feet by 7 inches by 4 inches, made out of old railway sleepers, each ... | 0 | 6 | 0 |
| Kerosene oil, per cwt. (9 lbs. = 1 gallon) ... ... | 10 | 8 | 0 |

RATES AT WARORA FOR CONTRACT WORK.

Excavation of foundation from 6 annas to 8 annas per 100 cubic feet.

Concrete in foundations, 20 rupees per 100 cubic feet.

Brick masonry on surface 10 rupees and 11 rupees, for lime and labour only, per 100 cubic feet.

Brick masonry underground 27 rupees 9 annas, including lime, labour, and bricks, per 100 cubic feet.

Lime costs to contractor 16 rupees 8 annas per 100 cubic feet.

Lime costs Government in making 15 rupees per 100 cubic feet.

Warora bricks, 1st class, 10 rupees per 1,000.

Warora bricks, 2nd class, 7 rupees 8 annas per 1,000.

Brick masonry underground, with 2nd class bricks, including lime, labour, and bricks, 23 rupees 12 annas per 100 cubic feet.

Basalt masonry underground, including lime, labour, and basalt, 24 rupees 10 annas per 100 cubic feet.

Basalt 4 rupees per 100 cubic feet.

Kampthi bricks, a better article, at Warora, 25 rupees per 1,000; brought a distance of 103 miles by rail, costing at Kampthi 8 rupees per 1,000.

Coursed rubble masonry, 50 rupees, 45 rupees, and 35 rupees, for lime and labour only, per 100 cubic feet.

Dressed stone masonry, 55 rupees, 60 rupees, 70 rupees, and 75 rupees per 100 cubic feet.

Undressed stone, 10 rupees per 100 cubic feet.

Dressed stone, 15 rupees per 100 cubic feet.

Dressed sandstone, 22 rupees per 100 cubic feet.

Lime pointing, 1 rupee 12 annas per 100 square feet.

Lime plaster, 4 rupees, 4 rupees 8 annas, and 5 rupees per 100 square feet.

Whitewashing, 2 rupees 8 annas per 1,000 square feet.

Colour washing, 2 rupees 9 annas per 1,000 square feet.

Whitewashing underground, 6 annas per 100 square feet.

Double tiling, Allahabad tiles, 10 rupees per 100 square feet labour only.

Material, 41 rupees per 100 square feet.

Single tiling, 6 rupees per 100 square feet, labour only.

Double round tiling, 16 rupees per 100 square feet, labour only.

Single tiling, 10 rupees per 100 square feet, for labour only.

Country tiles, 3 rupees 8 annas per 100 square feet, labour only.

Bamboo matting, 3 rupees per square foot.

Lime kunker, 2 rupees 8 annas, 3 rupees 12 annas, and 4 rupees per 100 cubic feet.

Sand, 3 rupees 8 annas per 100 cubic feet.

Thatching, 3 rupees 8 annas per 100 square feet per 3 inch thickness, and for every additional inch thickness, 1 rupee per 100 square feet

## IRON ORE NEAR WARORA.

In the immediate neighbourhood of Warora iron ore of excellent quality, and in large quantities, is found in metamorphic rocks, and the Government of India have been at some trouble and expense to find out whether it would pay with the present fuel obtainable at Warora to make iron. The principal places where iron ores are found in the coal district under review are Khandeshar Hill, near Dewalgaon, Lohara Hill, Pipalgaon, and at Ratnapur. All the ores are devoid of phosphorus, an advantage which increases their value. Mr. W. Ness, the Mining Engineer at Warora, in 1877, made some trials with an experimental furnace at Warora, which proved that with Warora coal iron making would be impracticable. Warora coal was tried at Towcester, England, in a Blair furnace, when it was found that the iron blooms made had a tendency to red-shortness, due probably to the sulphur in the coal. Washing and picking the coal was suggested.

The question of bringing the ore to England, and selling it, was gone into, when it was found that, in the opinion of large iron-masters, the ore might sell for 15s. to 32s. a ton, delivered at English ports. It was found also, from trials with the ore in England, that it was capable of being made into high-class tool steel. Iron made was tried at Woolwich by Mr. D. Kirkaldy, in December, 1877, when it was found that the ultimate tensile stress of Warora iron per square inch of original area, was from 20·3 tons to 22·5 tons. The appearance of the fracture was fibrous.

Mr. Ness was sent to England in 1878, and in a report to the Indian Government, on trials made in England, it seems that the Blair furnace was pronounced a failure as regards Indian iron, and he suggested to first reduce the iron to a metallic sponge, and then melt it in a gas furnace.

One of the ores known as Lohara, was pronounced by Mr. G. J. Snelus, in a report to the Indian Government, dated October 6th, 1881, to be a very pure ore, consisting principally of magnetic oxide with exceedingly small percentages of impurities. It is

eminently suited for making iron to be ultimately converted into steel, and would be also suitable for direct conversion should any really successful process be devised.

| | |
|---|---|
| Peroxide of iron ... ... ... ... | 88·098 |
| Protoxide ... ... ... ... ... | 8·506 |
| Peroxide of manganese ... ... ... | ·310 |
| Insoluble earthy matter ... ... ... | ·990 |
| Alumina soluble ... ... ... ... | 1·550 |
| Lime ... ... ... ... ... ... | trace |
| Magnesia ... ... ... ... ... | trace |
| Phosphoric acid ... ... ... ... | ·038 |
| Sulphur ... ... ... ... ... | trace |
| | 99·492 |
| Total metallic iron ... ... ... | 68·289 |

Another iron ore from Pipulgaon, Mr. Snelus pronounced a brown hematite.

| | |
|---|---|
| Peroxide of iron ... ... ... ... | 67·575 |
| Protoxide ... ... ... ... ... | nil |
| Peroxide of manganese ... ... ... | 2·326 |
| Insoluble residue (chiefly silica) ... . . | 14·400 |
| Alumina ... ... ... ... ... | 2·700 |
| Lime ... ... ... ... ... ... | 1·390 |
| Magnesia ... ... ... ... ... | trace |
| Phosphoric acid ... ... ... ... | 1·45 |
| Sulphur ... ... ... ... ... | trace |
| Combined water and carbonic acid ... ... | 10·500 |
| | 100·341 |
| Total metallic iron ... ... ... | 47·302 |

Limestone from Warora analysed gave:—

| | |
|---|---|
| Lime ... ... ... ... ... ... | 35·52 |
| Carbonic acid ... ... ... ... ... | 31·80 |
| Insoluble residue ... ... ... ... | 25·40 |
| Alumina and oxide of iron ... ... ... | 5·80 |
| Magnesia ... ... ... ... ... | ·22 |
| Phosphoric acid... ... ... ... ... | trace |
| | 98·74 |

An inferior limestone for smelting purposes.

Two limestones are found near Warora, one in the Vindhyan and the other in the Lameta series of rocks. The former is met with six miles north of Warora, at Khandara.

Two analyses from Mr. Hughes' paper already quoted are given as under:—

| | Vindhyan. Per cent. | | Lameta. Per cent. |
|---|---|---|---|
| Carbonate of lime and magnesia... | 96·8 | ... | 94·5 |
| Oxides of iron and alumina ... | 1·2 | ... | 3·0 |
| Phosphoric acid ... ... ... | trace | ... | trace |
| Insoluble ... ... ... ... | 2·0 | ... | 2·5 |

The carbonate of lime in the Lameta variety varies from 50 to 80 per cent.

"It is evident that if Warora coal is used in a blast furnace," Mr. Snelus goes on to say, "a large amount of lime will be needed to flux away the ash, and to take up the sulphur, and the fixed carbon, being so small in quantity, would entail a large consumption of fuel. From its inability to coke the coal, it is evident it must be used in a raw state, but the difficulties to be contended with, are the large proportion of sulphur and ash, and the tendency of the coal to decrepitate."

"If any means of making iron could be discovered, by which the fuel could be kept separate from the ore, these difficulties would be greatly reduced. Mr. Ness was, therefore, quite justified in proving, so far as he could, the practicability or otherwise of the various direct processes of iron making. Being thoroughly conversant with the experiments, which he and others have made with a view to reduce iron ores direct to the metallic state without contact with the fuel, and having had the opportunity of personally witnessing many of the attempts, especially those by the Blair process, conducted by Mr. Ireland and Mr. S. Siemens at Towcester, I am quite of opinion that, at present, all direct processes of reduction are experimental, and that they are, therefore, not applicable to the production of iron in India. There is no doubt that iron can be made by several of these processes, and that when such high class ores as the Lohara are used, very fine iron is the result, and consequently, if this is used for making steel, the quality of the product is excellent. But the waste of material, and the cost of manufacture places the schemes beyond the pale of practical iron making processes at present. Further experiment and some modification of the plans may ultimately lead to success, but it is clearly much easier to succeed with such new processes when using

undeniable raw materials, than when one of these is of doubtful quality. It is also clear that experiments of this kind are more likely to be successful when prosecuted in the midst of iron makers than they would be if attempted in a country where the labourers are totally unacquainted with iron making, and where skilled labour is most difficult to obtain."

Mr. Snelus goes on to say that, "Until these methods are removed from the domain of experiments, it would be folly to apply them to the production of iron from Indian minerals, and still greater folly to attempt to perfect such processes in India. Experiments should be carried out in this country in a properly-constructed modern furnace, with all the appliances of hot-blast, &c., to see if Indian coal can be used in the blast furnace in the raw state with success. The experiments should be carried on for at least a month with 4,000 to 5,000 tons of coals, and, if carried out with skill, would be a conclusive test."

After this report, experiments were carried out in India to make coke, which resulted in downright failure. Mr. Snelus, on being advised of the result of the coking experiments, states that he is not at all surprised at the result, and that it is quite evident the coal does not possess the slightest coking property. It should be here mentioned that, in 1879, Mr. William Hackney, Newport, Mon., made a report to the Indian Government on the iron ore and coal of the Chanda District of the Central Provinces, in which Mr. Hackney criticises the experimental furnace at Warora erected by Mr. Ness. It is needless to state that after Mr. Snelus' report, no more steps have been taken by the Government in this matter, and the whole question remains as it did then, viz., 1881.

## CONCLUSION.

From the foregoing notes it will be seen that Warora coal has now established a market in India, and as to its future, that depends entirely as to how the Government will spend more capital in keeping up the output at present attained.

The coal is certainly not a first-rate coal, but that is only a secondary consideration in a country where good English fuel costs so much; but of the first importance is it that there should be a sufficient quantity of it in the market to meet the demand, for otherwise its value as a cheap fuel will be diminished. It has at present no competition, and thus its price (delivered to large consumers at 4 rupees 4 annas and 4 rupees 8 annas) is very

reasonable, compared to the cost in raising it, and the price of English coal, which at Warora cost 34 rupees per ton.

Legitimate private enterprise would do extremely well in this coal-field; large tracts of coal exists besides that at Warora. A small tract at Bandur, some 20 miles north of Warora, would just be as near the Great Indian Peninsular Railway as Warora. Again, further south, as at Chanda, Ghujus, and east at Pisgaon, coal has been found to extend over several square miles, and of great thickness.

When the railway of the Bengal-Nagpore Company is opened, competition will exist from the Umaria Mine, some 200 miles off, and Raniganj, nearly 700 miles. Singareni coal may compete from the south, should the railway now proposed be continued from Warora south to Chanda and Warangal.

But even when these collieries are touched by railways running near Warora, the demand must always be increasing, especially as now English coal is rising in price. It is a strange fact that by private enterprise more is accomplished, than by governments in managing industries; there is not that vast amount of machinery to set in motion in private enterprise; things are managed by one man, instead of in a government by several who each in their turn have to refer to higher authority, and so on, till the Government of India is reached. Warora in the hands of an energetic private company would do better than any other colliery in India, owing to absence of competition.

What the future of Warora and Chanda may be as regards iron manufacture is difficult to foretell, the report of experts, so far, do not seem encouraging, in fact far from it; and it seems sad to think that the vast accumulations of good iron ore should now have to lie dormant.

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The PRESIDENT said Mr. Bunning had brought before them a most voluminous and interesting paper relating to coal mining in India, of which they practically knew little. He was afraid it would be impossible to do anything that day in the way of discussing the paper, which required careful reading and minute study to make them acquainted with the valuable information which it contained. He moved a vote of thanks to Mr. Bunning for the great care and amount of time he had devoted to preparing the valuable information contained in the paper.

Mr. Thomas Bell (H.M. Inspector of Mines) seconded the vote of thanks, and said he was very glad to notice that the number of accidents in India compared very favourably with England.

The vote of thanks was agreed to.

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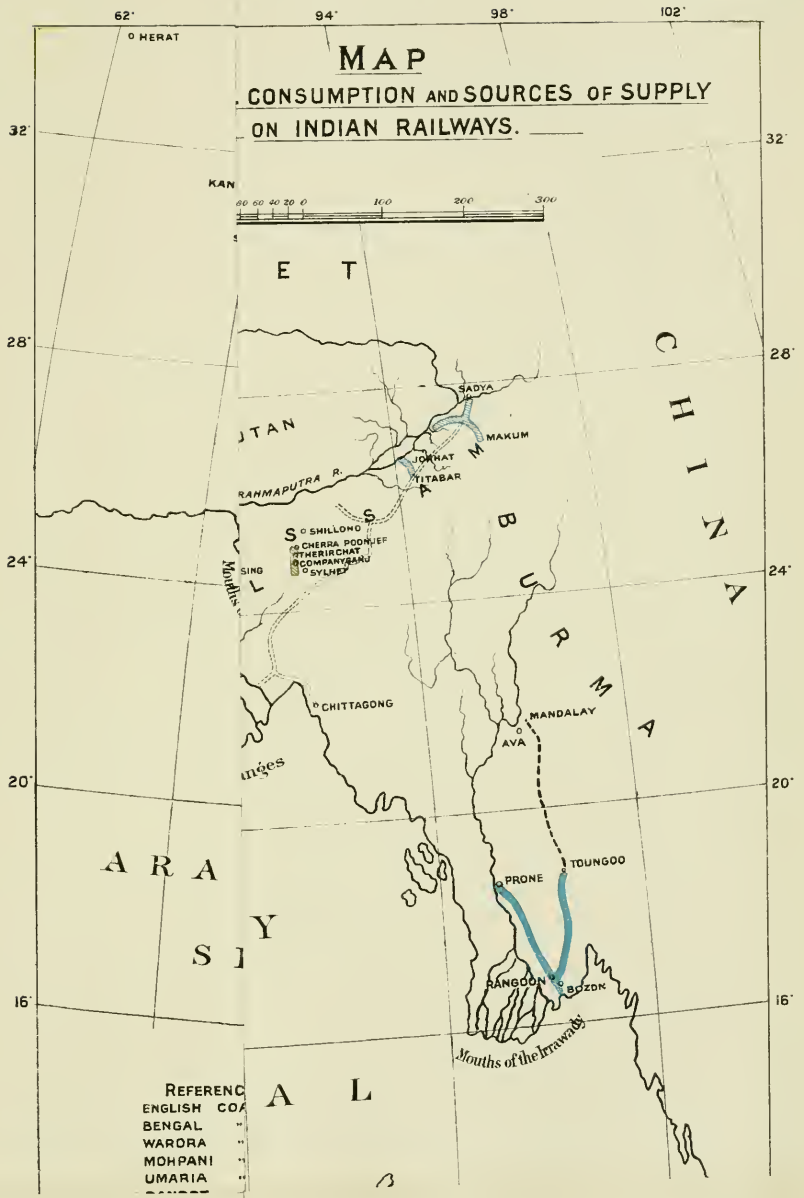
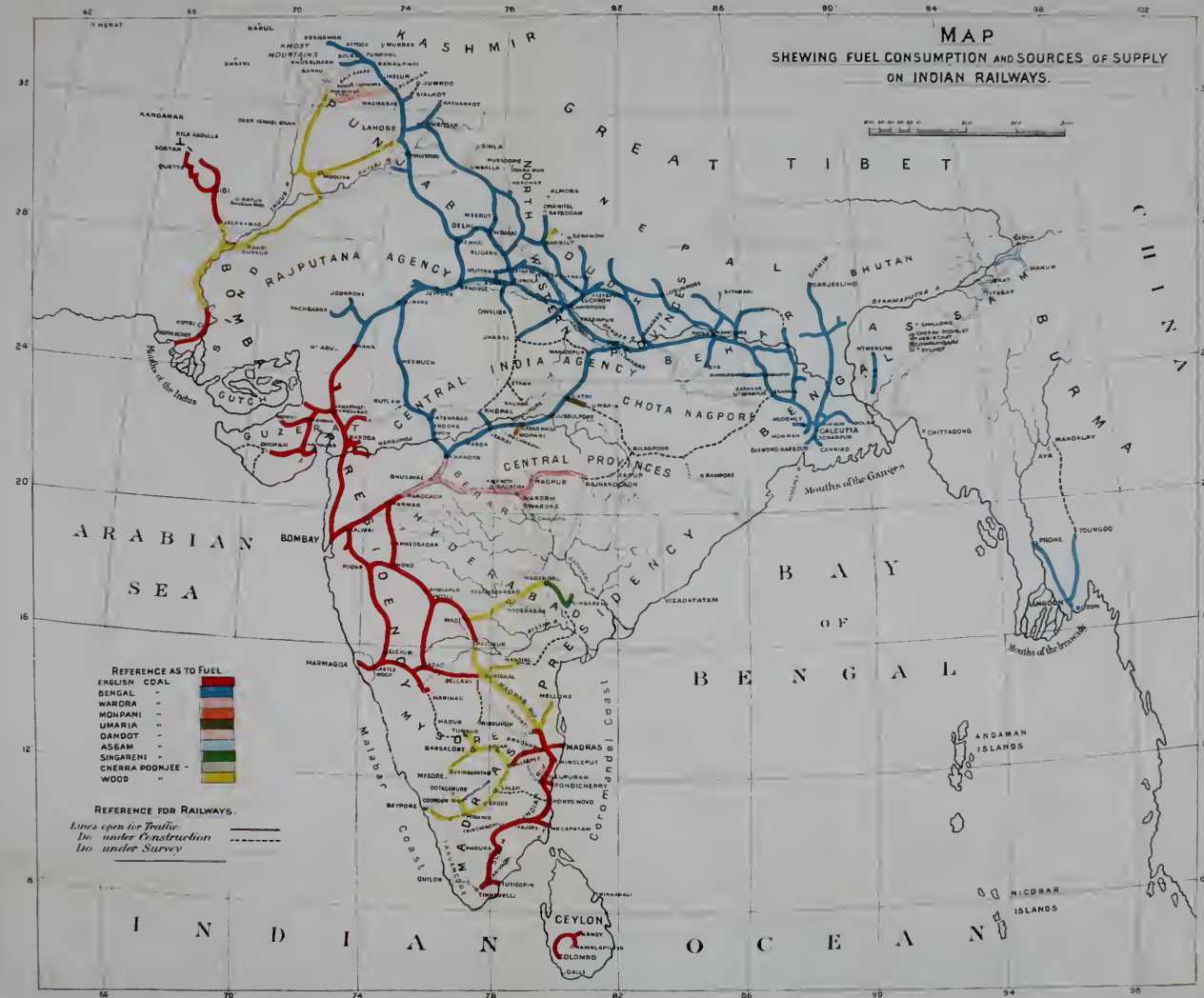
The following paper, by Mr. John M. Liddell, on "The Gold-fields of the Valley of De Kaap, Transvaal, South Africa," was read:—

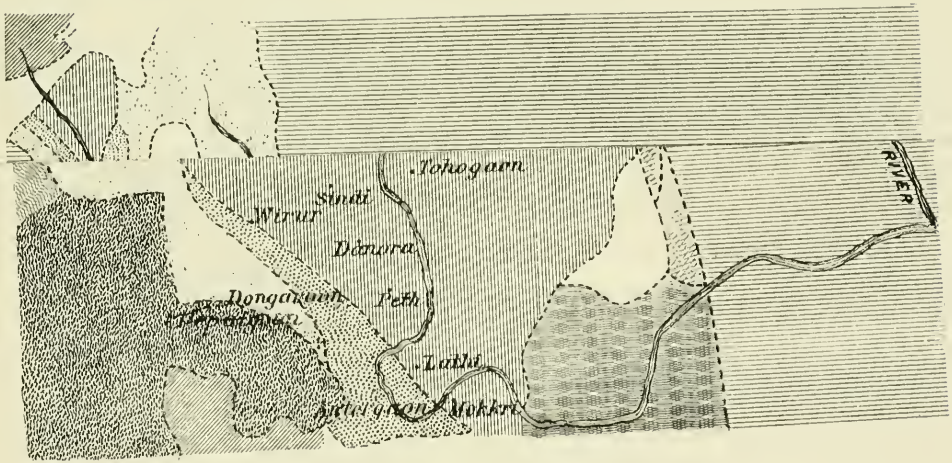

MAP
. CONSUMPTION AND SOURCES OF SUPPLY
ON INDIAN RAILWAYS.
62°
94°
98°
102°
32°
28°
24°
20°
16°
HERAT
KAN
E T
UTAN
C H I N A
SADYA
MAKUM
JORHAT
TITABAR
A M
RANMAPUTRA R.
SHILLONG
CHERRA POONJEE
THERIAGHAT
COMPANYGANJ
SYLHET
SING
B U R M A
CHITTAGONG
MANDALAY
AVA
TOUNGOO
PRONE
RANGOON
BOZOK
Mouths of the Irrawady
A R A
S E A
REFERENC
ENGLISH CO
BENGAL
WARORA
MOHPANI
UMARIA


MAP
SHEWING FUEL CONSUMPTION AND SOURCES OF SUPPLY
ON INDIAN RAILWAYS.
REFERENCE AS TO FUEL
ENGLISH COAL
BENGAL
WARORA
MOHPANI
UMARIA
DANDOT
ASSAM
SINGARENI
CHERRA PODHJEE
WOOD
REFERENCE FOR RAILWAYS.
Lines open for Traffic
Do. under Construction
Do. under Survey
KASHMIR
GREAT TIBET
NEPAL
BHUTAN
RAJPUTANA AGENCY
CENTRAL INDIA AGENCY
CHOTA NAGPORE
CENTRAL PROVINCES
BERAR
HYDERABAD
MYSORE
BOMBAY PRESIDENCY
MADRAS PRESIDENCY
BENGAL
ASSAM
BURMA
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
CEYLON
ANDAMAN ISLANDS
NICOBAR ISLANDS
Mouths of the Indus
Mouths of the Ganges
Mouths of the Irrawaddy
Malabar Coast
Coromandel Coast
BOMBAY
CALCUTTA
MADRAS
RANGOON

*To illustrate Mr. J. M. Liddell's Paper on "The De Kaap Goldfield."*

Lamb & Co. Lt. Newcastle

*ıg's Paper on "The Warora Coalfield."*

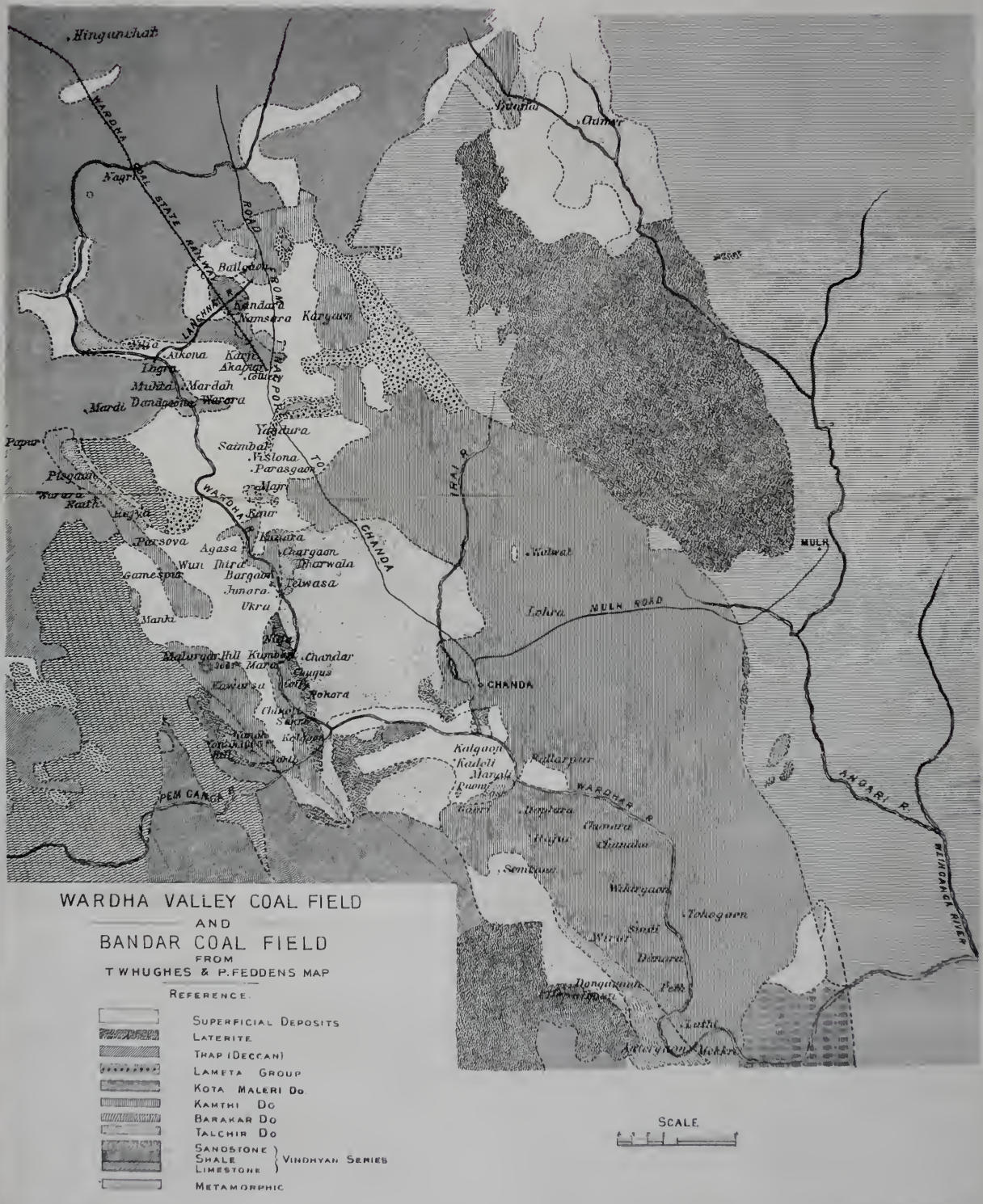



SCALE

4 3 2 1 4

Lambert & Co Lp Newcastle.

*To illustrate Mr. C. Z. Bunning's Paper on "The Warora Coalfield."*



# THE GOLD-FIELDS OF THE VALLEY OF DE KAAP, TRANSVAAL, SOUTH AFRICA.

By J. M. LIDDELL, Barberton, Transvaal.

The Gold-fields of De Kaap are situated in a belt of country stretching from the eastern edge of the great plateau of South Africa eastward down its slopes and spurs to the low-lying plain which is enclosed by the Lobombo Range. In this belt quartz reefs innumerable occur, and in the reefs gold is frequently developed. The rock systems containing the reefs are various, including granite, or, perhaps more correctly, syenite, beds of trap, slates or mudstones, quartzites, and others. The district in which the best discoveries have been made is occupied by a range of hills which runs out N.E. from the plateau, varying in height from one thousand to two thousand feet above the adjoining Kaap Valley, and from three thousand to four thousand feet above sea level. This range is called the Makonjwa. It is chiefly composed of beds of a quartzitic and slaty character, which have been tilted at a high angle (some 70 to 90 degs.) to the horizon: their line of strike runs roughly N.E., and their general dip is about S.E. They are, for the most part, very hard, and are intersected by dykes and pipes of whinstone, which frequently cross the line of strike at a high angle. The range is divided into sharp ridges by deep longitudinal glens, locally called *kloofs*. It is adjoined on the N.W. by a large, open, undulating valley of granite (or syenite), and by a range of hills composed of granitic rocks, and on the S.E. by another *massif* of quartzites, slates, &c. The Makonjwa extends thus from the plateau on the S.W. for a distance of some 50 miles, till it dies away in low ridges and detached hills into the flat, low "veldt" country on the N.E.

Travelling N.E. from the town of Barberton, which lies at the base of the range on the N.W. side and about midway along its flank, the beds thicken considerably, till at a distance of about 12 or 14 miles a number of them appear to nip out entirely, causing this part of the range first to widen gradually and then to terminate abruptly. A knot of comparatively isolated hills is thus formed, which is commonly known as the "Sheba Hill."

Along the main ridge of the Sheba Hill runs a conspicuous crest formed by an outcrop of light grey quartz rock, clearly traceable for a mile and a third, and lost at each end in the deep wooded kloofs which divide its spurs. At a point (X on Plan) at the N.E. end a gold-bearing lode of light grey quartz was discovered outcropping down in the steep face of the hill and varying in thickness up to 6 feet; in this a mine was opened and called the Nil-desperandum (see Plan). The outcrop of the covering quartzite bed has been opened and explored for about 2 miles to the S.W. but, as yet, without discovering the extension of the main lode. To the N.E., the lode was followed across a deep kloof to a cliff (or kranty) of which it formed the face (Y on Plan), the hanging wall or covering bed having been denuded. Eastward yet, across a second kloof it was opened in the face of a spur of the hill and there found to have developed into a peculiar formation in which a party of prospectors, led by Mr. Bray, opened their famous "Golden Quarry" which, with other claims adjacent, has become the property of the Sheba Gold Mining Company, Limited (see Plan).

The ore has been quarried out at this point until an excavation over 70 feet in diameter has been made in the length and width of the lode, the whole yielding richly, and showing a considerable amount of visible gold; it has been opened further by day-drifts at intervals down the face of the slope below to a depth of about 200 feet and proved to continue both rich and thick. The precise nature of this formation has been a puzzle, and many opinions have been expressed as to whether it is a pipe in the main lode, or a cross lode, either running from or dependent on the main lode. The first crushing of stone from this property was taken from the surface at the original quarry and gave an average yield of over 8 ounces per ton. The published yields by subsequent crushings have run from 3 to 4 ounces per ton at the first treatment of the ore The ore from this formation is apparently a very hard quartzite, of varying shades of greyish blue and green, intersected by thin veins of white quartz, showing cleavage planes discoloured by iron, especially near the surface. The formation itself shows regular lines of bedding and jointing independent of the gold shoot, which cause much difficulty in discovering the direction and character of the lode itself. It is exceedingly hard and cannot be distinguished from the bed immediately below it except by the proportion of gold it contains.

Eastward from the above property the gold-bearing lode has not been proved to exist, though the outcrop of the covering quartzite beds is clearly traceable. The main lode itself is thus proved for a distance on the surface of about 3,000 feet. From the Nil-desperandum S.W. to the end of the Hill (Z) though the main lode has not been found, the whole of the beds to the northern side, that is, the beds next below the lode in the formation, are found to be intersected at frequent intervals by veins of quartz, which extend N. and W. from the main reef line at high angles with the latter, and intersect the beds in a most capriciously intricate manner. The colour of the quartz in these cross-veins is dark blue, shading into black (see specimen), and their lustre highly vitreous, in which features they vary distinctly from the quartz of the main lode. They contain a large amount of gold, some tests and crushings having yielded in the mill at the rate of tens of ounces per ton. Their continuity is much interrupted, and they commonly thin out or split until lost in the quartzite beds, sometimes disappearing without definite termination, as if absorbed by the rock, and again appearing in rich shoots and pockets. The gold is sometimes found in the quartzite walls, rather than in the quartz vein. It is further to be observed, that all the cross-veins extending thus from the main line run to the N.W. side or foot-wall of the reef, while though there are reefs parallel to the main line on the S.E., or hanging-wall side of it, few, if any, of them, have been found to contain gold, and no lode of any value has been worked. This fact causes speculation as to whether all the cross-veins on the N.W. side have intruded into cracks in the foot-wall from the main-lode. The former have been traced, and opened at distances varying up to 5,000 feet, apparently too far for veins of so erratic a nature to extend from the parent lode, but no lode parallel to the latter on the N.W. side has yet been proved.

Curious irregular cavities occur in and about the rich veins, sometimes empty, sometimes partly filled with earthy incrustations or containing a sooty deposit resembling the black, woolly material found on the coke of a fresh drawn oven. There are also patches of honeycombed quartz, of which the vesicles contain particles of flower gold. The appearance of these chimneys and honeycombs suggests the idea that the gold and its matrix came up hot from below, and that each vesicle was blown out as a bubble by gold in a gaseous state, which condensed after the quartz had cooled and crystallised. This matter, however, must be left for the close study

of specialists, as must also the general formation of the hill. It is a matter of the greatest local interest to discover whether there is one parent lode from which all the cross-lodes have sprung, or whether there are parallel lodes on the north-west side of the Sheba lode. Further, there is a question as to whether the main lode (Sheba) was deposited as a bed before the strata were tilted, or was afterwards intruded between the beds. The irregularity in thickness and continuity of the lode seems to favour the theory of intrusion, but in either case it is difficult to find a reason for its difference in texture and colour from the cross-veins.

There is one coincidence observable which appears to have an important bearing on the occurrence of gold shoots, viz., the frequent proximity of whin-dykes, and the fact that near the point where a dyke crosses the lode a rich shoot or pocket of gold is not infrequently found. The dykes and the quartzite beds which they traverse are extremely hard and difficult to drill in. In the granitic parts of the country the lodes more commonly run parallel to the dykes, but as the granitic rocks are almost, if not entirely, devoid of bedding, there is no obstruction likely to defleet them from the line followed by the dyke.

In so rough and disturbed a country there is endless matter for geological study and speculation, but a survey is desirable to discover with any useful precision the relative positions of its salient features, and this in itself requires no slight labour and expense. Some attempt is, however, being made by Civil Engineers of the district to accumulate accurate information as to its topography and outcrops, and it may be hoped that geologists will thus be provided with a means of investigation, which should assist them in throwing considerable light on the development of gold.

The opening of mines on the Kaap Gold-fields has brought out in a marked degree the difficulties attending all engineering work in South Africa. The most troublesome is that of transport. The means usual in the country, prior to the construction of railways, is the buck-wagon, which carries from 3 to 4 tons weight of material, and is drawn by a span or team of 16 oxen over rough, roadless country. An ox-wagon can be worked on a gradient of 1 in 10, but there are many main routes on the Kaap Fields on which that gradient is exceeded, and sledges are used, of course, for the downward transport only. There are no cattle yet sufficiently acclimatised to be reliable throughout the year, and the

want of grass late in winter renders feeding scarce and costly. The mountains are, moreover, so rough that the routes are circuitous, the speed is of the slowest, and the cost per ton per mile is enormous. A large amount of general material is carried over the hills by natives, who have an opportune capacity of travelling for days with individual loads of 60 to 70 lbs. on their heads. Donkeys are also in constant use, as they alone stand the climate to any reliable extent. It is hoped, however, that railways and tramways will shortly take the heaviest of the transport, and aerial wire-rope trams are doing much good work. Where possible, the mills are driven by water-power, of which there is a considerable fund in the Queen's River, which skirts the western base of the Sheba Hill, and the principal mills are distributed along its banks. But, as this involves a long transport of the ore, properties situated on the hill-tops are seriously handicapped, and the project of transmitting power by electricity to points near the mines, where there is water sufficient for amalgamation plates, has been much discussed. Many mills are driven by steam, for which purpose the local firewood supply will last a few years. Coal, unfortunately, is too expensive, and, until the Delagoa Bay Railway becomes a fact, on the Kaap Fields many large properties of low grade ore must remain dormant.

Much attention is directed to the improvement of milling machinery. The Sandycroft battery has so far the best average of advantages; but there are serious objections to it on account of its weight, the massiveness of its parts, number of bearances, motive power required, &c. It is difficult to handle large pieces of metal while in transport over a rough country, and it is frequently difficult to economise motive power to the last degree. Many new patterns and principles of treatment have been tried, including a most important method of separating gold without the help of water. There is a tendency to send new styles of machinery out before they are thoroughly tested at home, which is commonly disastrous, but it may be hoped that these questions will be thoroughly digested and worked out, for the gold industry of South Africa is only at its dawn, and the area of country known to be rich, but unworked during modern times, or since the steam engine was invented, is so great as to be practically inexhaustible.

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On the motion of the PRESIDENT, a vote of thanks was accorded the writer for his paper.

# THE PIELER SPIRIT-LAMP AS A FIRE-DAMP INDICATOR.

By M. WALTON BROWN.

THE Pieler spirit-lamp affords probably one of the simplest methods of examining the air in the pit with regard to the existence of fire-damp.

It consists essentially of a large Davy lamp (Plate V.) constructed to burn alcohol. A circular wick (*a*) is employed (preferably made of silk) which is passed over a round tube (*b*), the height of which can be varied by means of a screw (*c*) passing through the bottom of the lamp. A short conical chimney (*d*) is placed around the flame, which is so regulated as not to appear above the top in an atmosphere of pure air.

When the lamp is placed in a mixture of fire-damp and air the spirit flame shows a conspicuous cone of light, very much larger than that produced by the flame of ordinary vegetable or animal oils.

This lamp should not, however, be used in a mixture of fire-damp and air in any way approaching explosive proportions, as the lamp becomes rapidly heated and its use dangerous under such conditions. As invented by Herr Pieler, it was intended to be used only in the laboratory upon samples of air taken in the mine. It may, however, be used in the mine, in the absence of bodies of fire-damp. It originally consisted of an unprotected safety lamp; its use in rapid currents in mines is facilitated, and its safety greatly enhanced, by the provision of an arrangement, devised by Mr. W. N. Atkinson, H.M. Inspector of Mines, consisting of a thin iron shield (*e*) (covering the whole of the lamp), fitted with holes at top and bottom, for the admission and exit of the air, together with a graduated glass window (*f*).

The reservoir of the lamp is filled with alcohol,* provision being made for the escape of any vapour into the centre of the wick tube in order to prevent accumulated pressure in the spirit reservoir. It

* Methylated spirit may be used, but it is not recommended.

frequently happens that this lamp is made with the wick tube of such a length as to nearly reach the bottom of the reservoir, and it will be readily recognised that if the reservoir becomes heated, large volumes of spirit vapour will be produced, the pressure of which will naturally raise the alcohol up the tube like a fountain. This danger may of course be avoided by care in charging, to see that the reservoir is not too full, and by the provision of small holes, (*g*) in the wick tube and surrounding tube, above the surface of the alcohol, through which the accumulated vapours can escape into and be consumed in the flame.

The conical chimney which is placed around the flame should be so arranged that its upper edge shall always be at the same height above the wick tube.

After the lamp is lighted the observer should take it into a perfectly dark chamber, in pure air, and when his eyes have become accustomed to the darkness, he should then proceed to adjust the alcohol flame so that its summit may neither be below or above, but shall coincide with the upper edge of the chimney. Great care should be exercised in this matter, as it is a very usual occurrence for people who may use this lamp for the first time to leave the flame above the top of the chimney, with the consequence that, when the lamp is taken into mixtures of fire-damp and air, exaggerated results are obtained. Thus it is possible, by careless adjustment of the flame in the beginning, to obtain a flame say, similar to that shown for $3\frac{1}{2}$ per cent. with smaller percentages of gas. The flame, whence once adjusted, should not be readjusted except in pure air.

The glass tube is preferably divided into half-inches by opaque lines drawn upon the glass, measured from and above a base line, below which the glass is wholly obscured; this base line being drawn at the level of the upper edge of the conical chimney.

Great care should be exercised in the use of this lamp in all mixtures containing 2 per cent. or more of fire-damp, owing to the lamp becoming heated by the flame, with the result that the alcohol flame is enlarged to a dangerous extent, possibly by the increased volatilisation and increased pressure of the spirit in the receiver. It may be also mentioned that the indications of the lamp are vitiated from the above-named cause when the lamp becomes slightly heated or is used in heated air currents. In stagnant air, the flame becomes less, owing to the gradual burning up of the fire-damp.

The following table contains the results of experiments made by Dr. K. Broockmann in the laboratory of the Prussian fire-damp commission, as to the phenomena produced by fire-damp in the Pieler spirit lamp* :—

With $\frac{1}{4}$ per cent. of $CH_4$ there is seen above the upper edge of the small conical chimney, a faint dun-coloured light, whose edges and tapered point are rendered indistinct by the reflection, and whose height is about $1\frac{1}{8}$ inches.

With $\frac{1}{2}$ per cent. of $CH_4$ the cone of light is 2 inches high, the base is about $\frac{1}{4}$ inch, the colour is bluish grey, not clearly visible.

With $\frac{3}{4}$ per cent. of $CH_4$ the cap or halo is about $2\frac{3}{8}$ inches high, the base is about $\frac{1}{4}$ inch, the colour dun to bluish, and the cone of light still indistinct.

With 1 per cent. of $CH_4$ the cap is about $3\frac{1}{8}$ inches high, the base about $\frac{3}{8}$ inch wide, the tapered point of the cone of light is not distinctly visible, and the colour bluish.

With $1\frac{1}{4}$ per cent. of $CH_4$ the brightness drowns the reflection, and the cone of light becomes clearly defined, its height is about $3\frac{1}{2}$ inches, and the colour blue.

With $1\frac{1}{2}$ per cent. of $CH_4$ the cap is 4 inches high, and of an intense blue colour.

With $1\frac{3}{4}$ per cent. of $CH_4$ the cap is $4\frac{3}{8}$ inches high, and of an intense blue colour.

With 2 per cent. of $CH_4$ the cap is $5\frac{1}{8}$ inches high, and of an intense blue colour.

With $2\frac{1}{4}$ per cent. of $CH_4$ the cap is $5\frac{1}{2}$ inches high, and of an intense blue colour. With this percentage the tapered point of the cone of light touches the cover of the wire gauze, and the base of the cone of light is about $\frac{5}{8}$ inch wide.

With $2\frac{1}{2}$ per cent. of $CH_4$ the cap illuminates the cover of the wire gauze cage at the place of contact.

With $2\frac{3}{4}$ per cent. of $CH_4$ the cap produces a dull red heat in the middle of the cover of the wire gauze cage.

With 3 per cent. of $CH_4$ the cap produces a red heat in the middle of the wire gauze cage, the top of the cone of light is $\frac{1}{4}$ inch wide below the cover, on which the top is slightly widened.

With $3\frac{1}{4}$ per cent. of $CH_4$ the phenomena are the same as with 3 per cent., save that the dimensions are slightly greater, and the top of the flame plays on the cover.

* Untersuchung der durch Sumpfgas hervorgebrachten Erscheinungen der Pieler-lampe. Anlagen zum Haupt-Berichte der Preussischen Schlagwetter Commission, Vol. I, pages 129 to 133, Vol. III., pages 167 to 173, plates 59 and 60.

With $3\frac{1}{2}$ per cent. of $CH_4$ the cap becomes almost cylindrical in form, the upper portion widens, and becomes of the same diameter as the cover of the wire gauze cage, and produces a red heat in the cover, and $\frac{1}{4}$ inch of the wire gauze; the bright yellow flame of the cone of the spirit flame is $\frac{1}{4}$ inch above the upper edge of the conical chimney.

With $3\frac{3}{4}$ per cent. of $CH_4$ the bright yellow cone is about $\frac{1}{4}$ inch high, the cover and $\frac{3}{8}$ inch of the wire gauze at red heat, the base is $\frac{5}{8}$ inch wide, the top below the widened portion about $\frac{1}{2}$ inch; the flame plays upon the wire gauze below.

With 4 per cent. of $CH_4$ there is intense red heat of the upper portions of the wire gauze cage (about $\frac{3}{4}$ inch), the cap is completely cylindrical, and plays violently on the wire gauze cage below, and the bright yellow cone of flame is $\frac{3}{8}$ inch high.

With $4\frac{1}{4}$ per cent. of $CH_4$ the upper portion of the cap widens and touches the wire gauze cage at a height of $4\frac{3}{4}$ inches, measured from the upper edge of the conical chimney; base $\frac{3}{4}$ inch wide, and yellow cone of light $\frac{3}{8}$ inch high; cover of the wire gauze cage and upper $\frac{3}{4}$ inch of the wire gauze cage at a red heat.

With $4\frac{1}{2}$ per cent. of $CH_4$ the cap touches the wire gauze cage at a height of 4 inches, base $\frac{3}{4}$ inch, and yellow cone $\frac{5}{8}$ inch high.

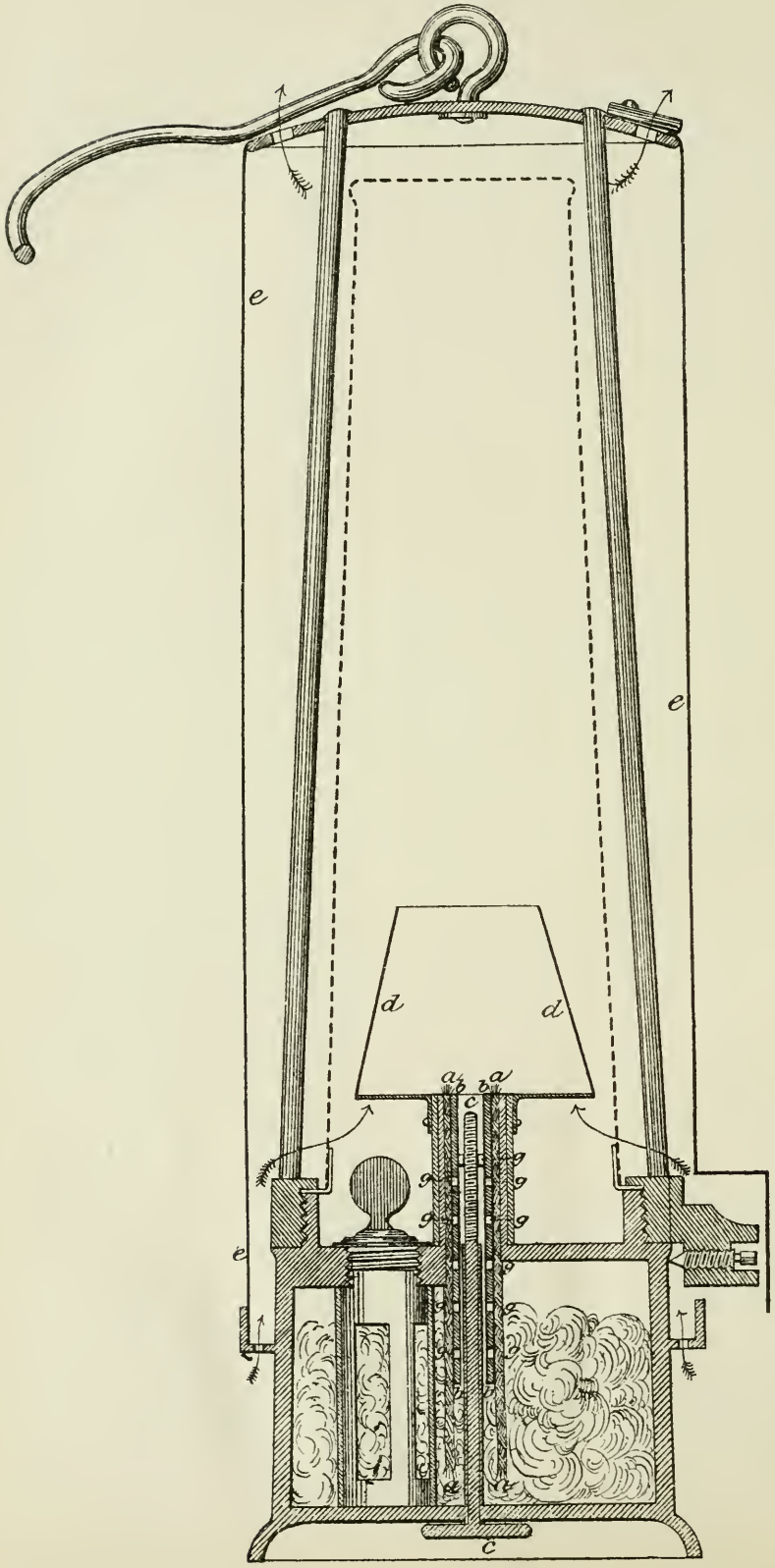
With $4\frac{3}{4}$ per cent. of $CH_4$ the cap touches the wire gauze cage at a height of $3\frac{1}{8}$ inches, the cover of the wire gauze cage and upper $1\frac{1}{8}$ inches of the wire gauze cage at a red heat, yellow cone of light $\frac{3}{4}$ inch, and base of the cap fills up the opening of the conical chimney.

With 5 per cent. of $CH_4$ the cap touches the wire gauze cage at 2 to $2\frac{3}{8}$ inches high, the down turned edge of the cap vibrates, the upper 2 inches of the wire gauze cage is at a red heat, and yellow cone of light 1 inch high.

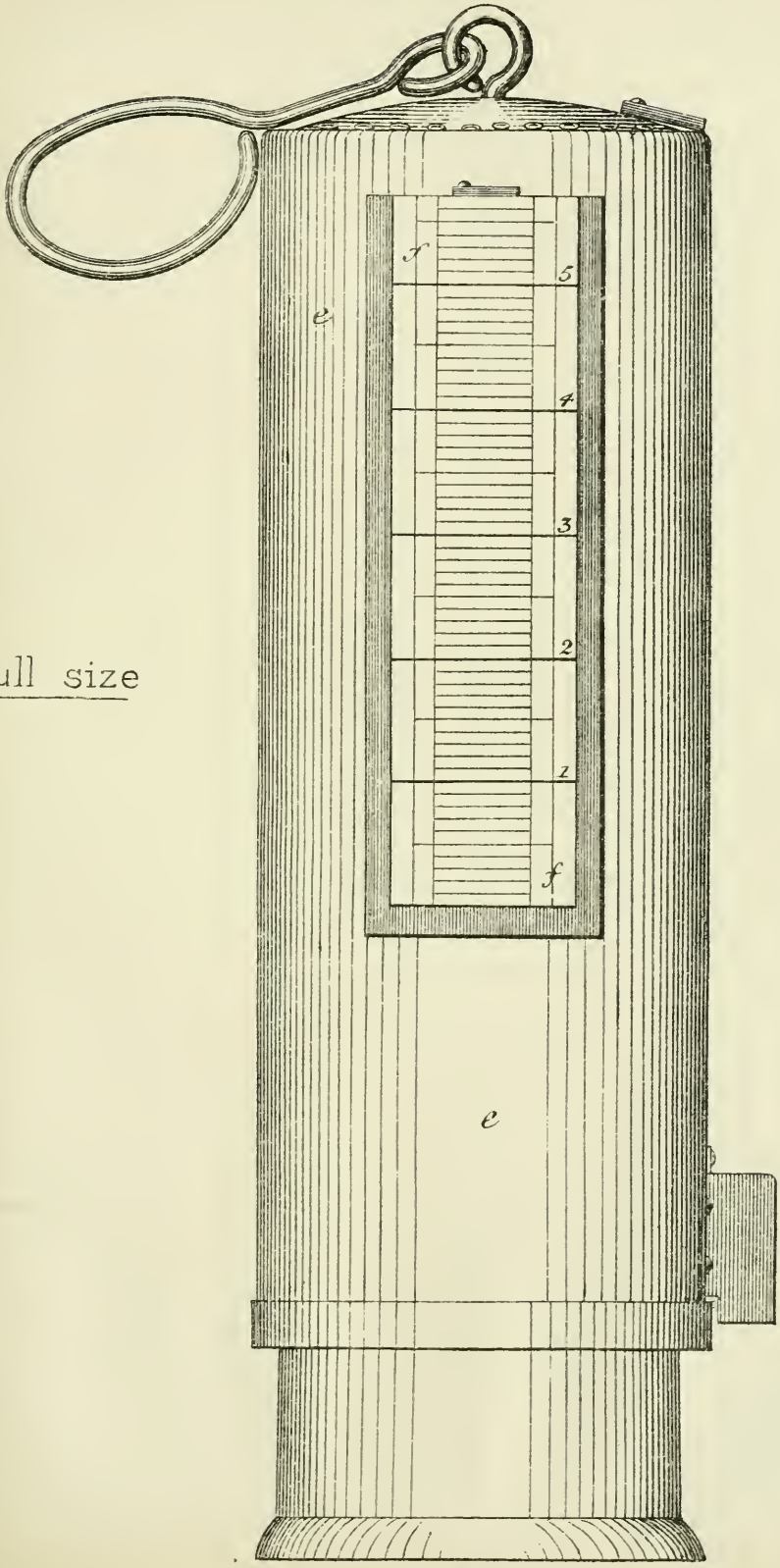
With $5\frac{1}{4}$ per cent. of $CH_4$ the cap takes a flat mushroom shape and touches the wire gauze cage at $1\frac{5}{8}$ inches high; a long stay in this percentage produces a surging agitation of the edge of the cap, and ultimately the whole of the wire gauze cage is filled.

It is scarcely possible to rely upon the indications as being absolutely exact, and the record should preferably be made in inches, and an approximate calculation of the percentage of gas obtained.

*To illustrate Mr. M. Walton Brown's Paper on*




Scale

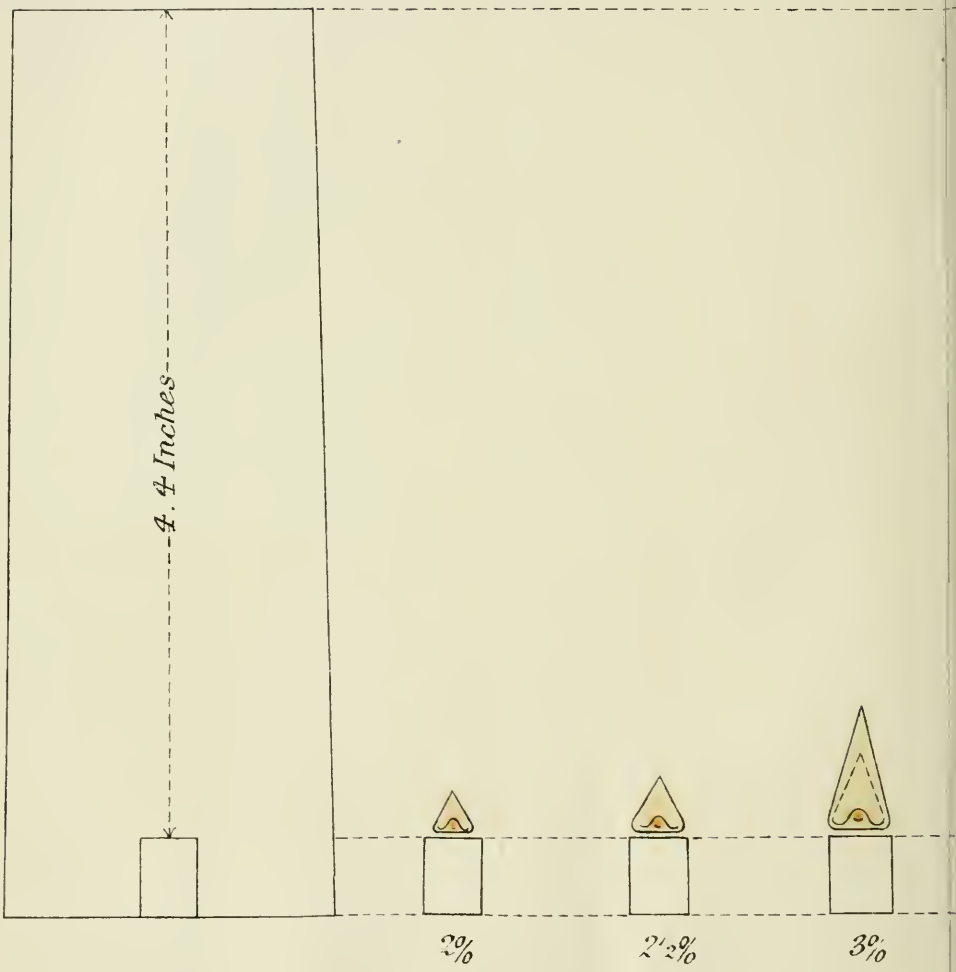



full size

Lambert & Co. Lt. Newcastle.

*To illustrate Mr. M. Walton Brown's Paper on "Ti*

APPEARANCES OF THE FLAME



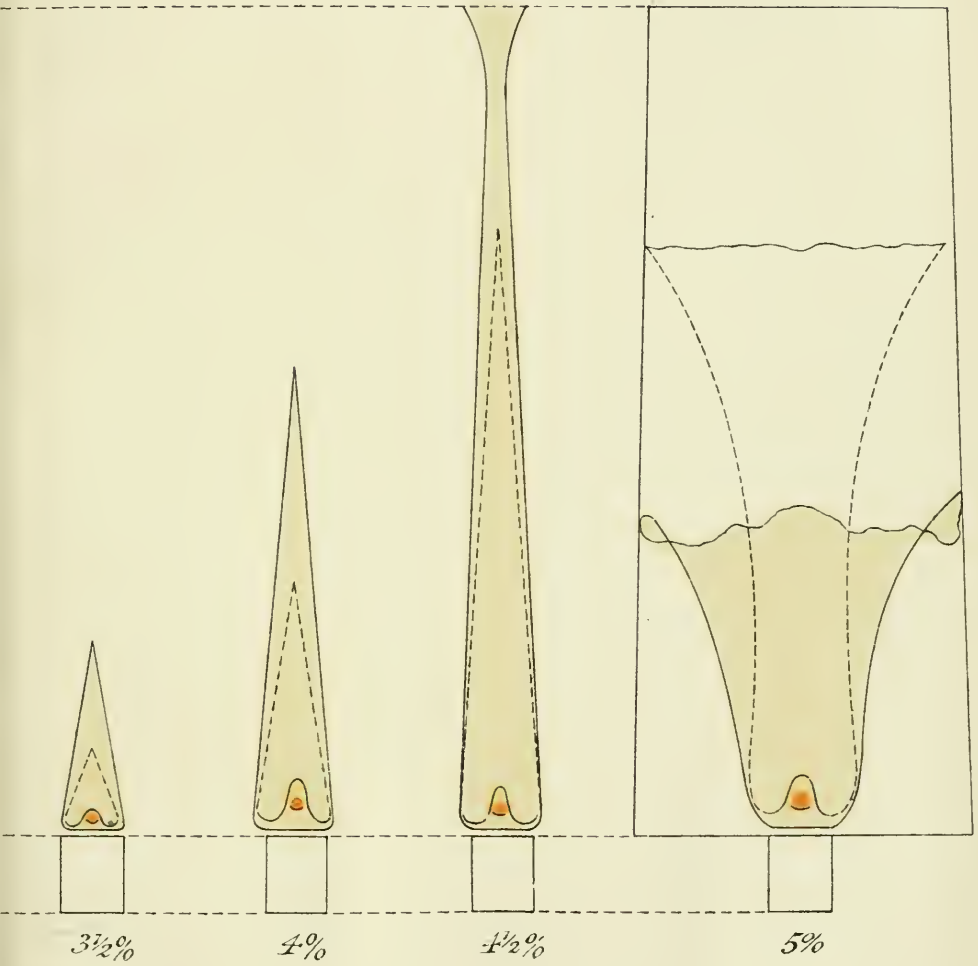

PERCENTAGES OF FIRE

With 5½ per cent. of fire-damp

FUI

*Pieler Spirit-Lamp as a Fire-damp Indicator."*

AND CAPS IN THE DAVY LAMP.



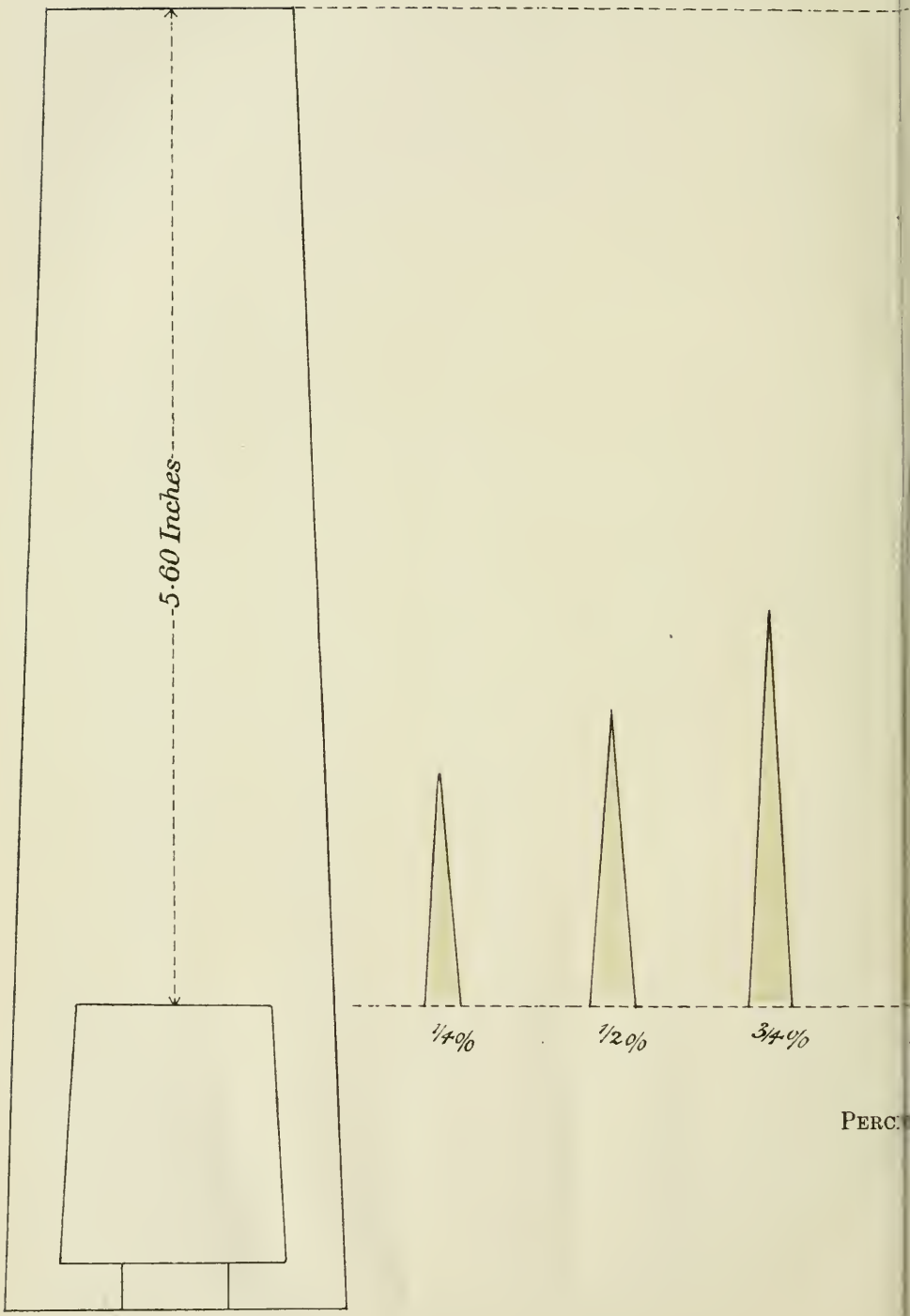

AMP ($CH_4$) IN THE AIR.

ıe flame fills the wire gauze cover.

SIZE.

*To illustrate Mr. M. Walton Brown's Paper on 'Th*

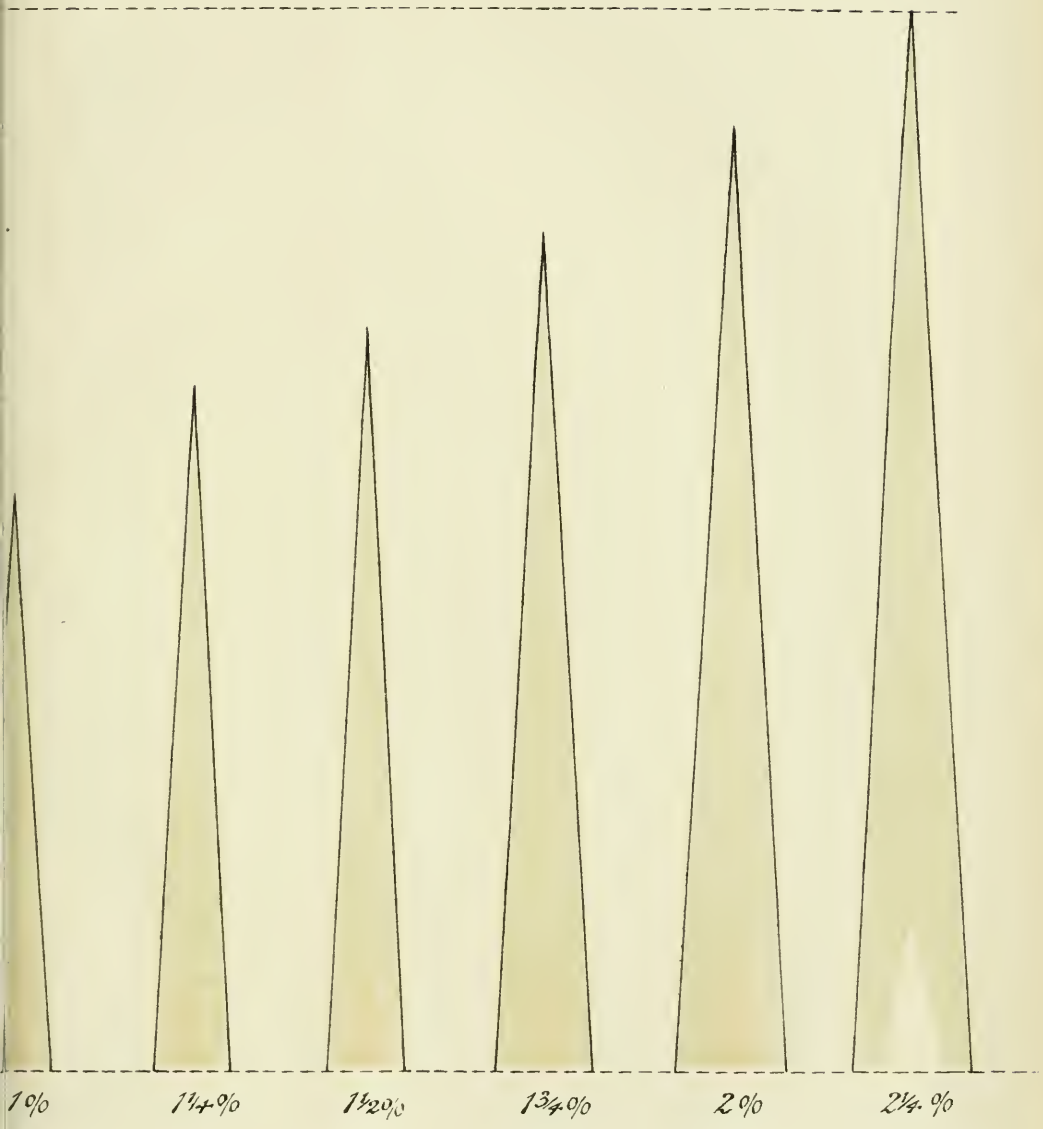
APPEARANCES OF THE FLAMES M




PERC

*'he Pieler Spirit-Lamp as a Fire-damp Indicator."*

ND CAPS IN THE PIELER SPIRIT-LAMP.

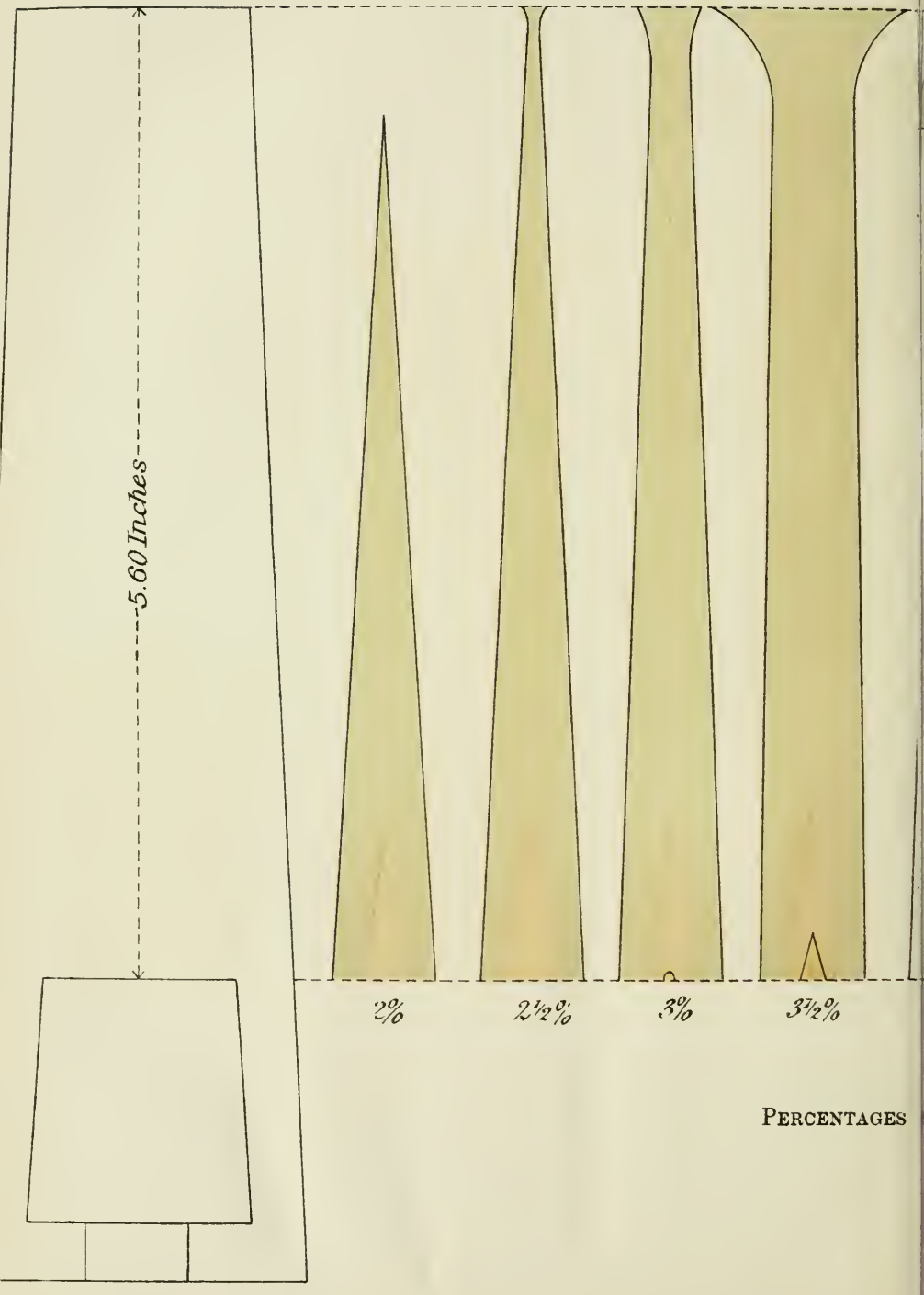



RAGES OF FIRE-DAMP ($CH_4$) IN THE AIR.

FULL SIZE.

*To illustrate Mr. M. Walton Brown's Paper on "*

APPEARANCES OF THE FLAMES AN

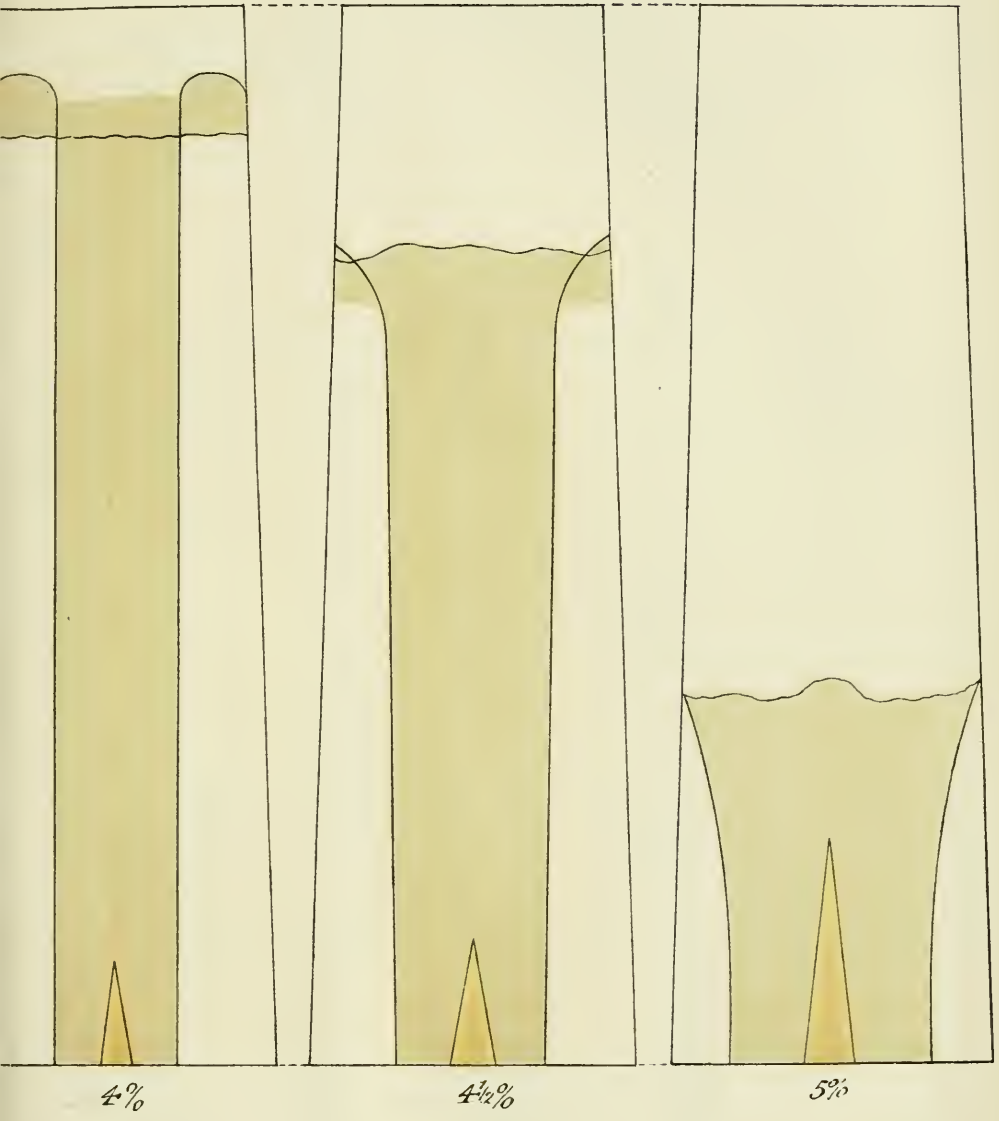



PERCENTAGES

*gs N° E1 of M& M.E. 1888-89*

*he Pieler Spirit-Lamp as a Fire-damp Indicator."*

CAPS IN THE PIELER SPIRIT-LAMP.




FIRE-DAMP ($CH_4$) IN THE AIR.

FULL SIZE.

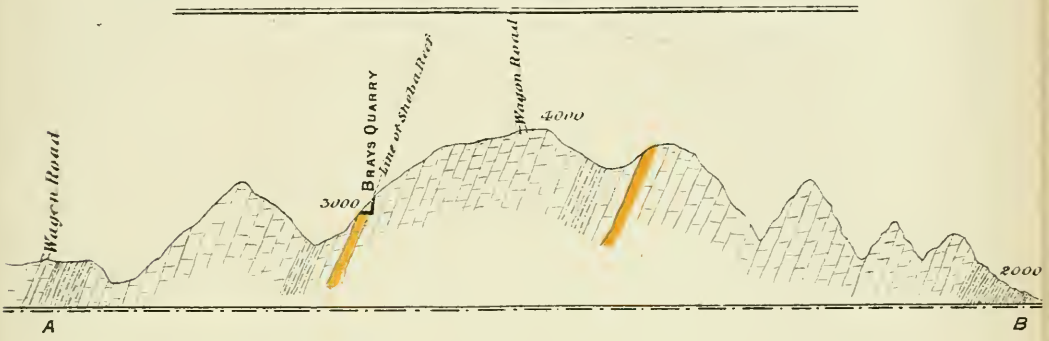
Lambert & Co. Ltd. Newcastle.

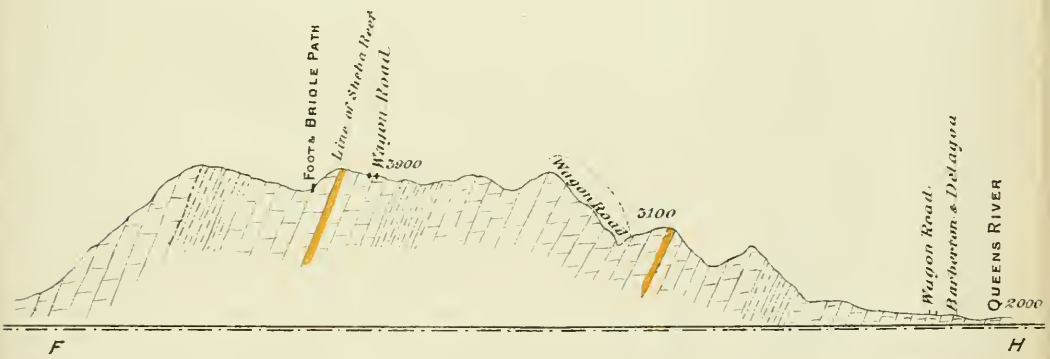
*To illustrate Mr. J. M. Liddell's Paper on "The De Kaap Goldfield."*

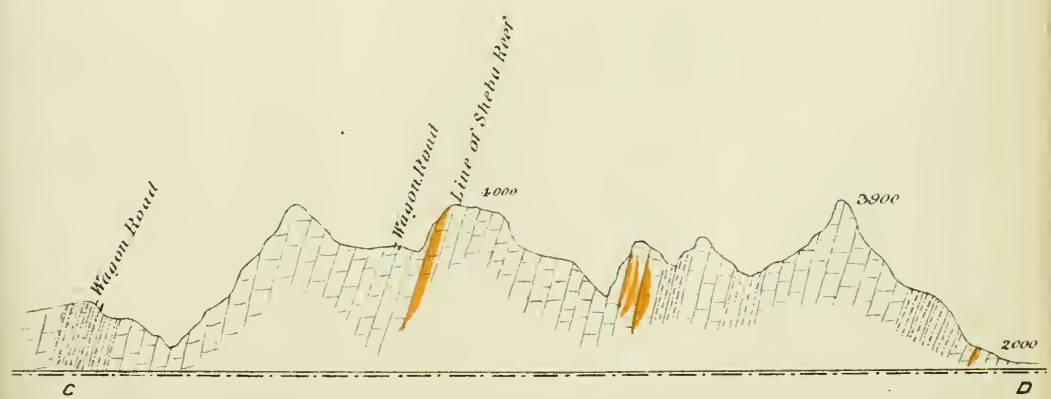


# CROSS SECTIONS
SKETCHED TO ILLUSTRATE
THE CONTOUR OF THE
# SHEBA HILL.

REFERENCE—GOLD BEARING REEFS & VEINS, QUARTZITE BED, SLATEY BEDS.
NUMBERS SHOW ROUGH ESTIMATED ALTITUDES ABOVE SEA LEVEL
DATUM ABOUT LEVEL OF QUEENS RIVER.



The following table contains practical results obtained by various lamps :—

HEIGHT OF THE CAP, WITH THE FLAME REDUCED AS MUCH AS POSSIBLE IN HEIGHT.

| Percentage of mine gas. | Pieler. (Alcohol). | Davy. | Boty. | Wolf. (Benzin). | Mueseler. |
|---|---|---|---|---|---|
| | Inches. | Inches. | Inches. | Inches. | Inches. |
| ¼ | 1·18 | ... | ... | ... | ... |
| ½ | 1·65 | ... | ... | ... | ... |
| ¾ | 2·16 | .. | ... | ... | ... |
| 1 | 2·95 | ... | ... | ... | ... |
| 1¼ | 3·54 | ... | ... | ... | ... |
| 1½ | 3 94 | ... | ... | ... | ... |
| 1¾ | 4·33 | ... | ... | ... | ... |
| 2 | 4·92 | ·23 | ·27 | ·43 | ... |
| 2½ | 5·51 The flame touches the top of the wire gauze cage, and has an upper diameter d = ·12 inch. | ·27 | ·39 | ·55 | ·20 |
| 3 | The same, d = ·35 inch. | ·63 | ·98 | ·83 | ·47 |
| 3½ | The same, d = 1·06 inches. | 1·02 | 1·50 | 1·69 | ·83 |
| 4 | The flame fills the upper portion of wire gauze cage for a length l = ·67 inch. | 2·40 | 2·20 | 2·64 | 1·18 The upper portion was hidden by the chimney. |
| 4½ | The same, l = 1·18 inches. | 4·25 The aureole reaches the cover of the lamp and forms a cone, whose upper diameter d = ·31 to ·35 inch. | 5·51 | 5·71 | 1·18 The same. |
| 5 | The same, l = 3·62 inches. | The aureole fills the upper part of the wire gauze cage for a length l = 2·60 inches | The aureole fills the wire gauze cage and whirls in the lamp, with rapid eddies into and within the glass cylinder below. | | 1·18 The same. |

The relative appearances of the flames and caps produced in the Davy lamp and Pieler spirit-lamp in mixtures of fire-damp and air, are shown in Plates VI., VII., and VIII.

Mr. J. A. Ramsay: As Mr. Pieler does not recommend methylated spirits for burning in the lamp, what particular kind of nourishment has Mr. Brown used in the lamp he is now showing to us?

Mr. Brown: Alcohol.

Mr. Berkley: What is the objection to methylated spirits?

Mr. Brown: With spirits the yellow flame begins to show with 3 per cent. of gas (Plate VIII.), but with methylated spirits it is seen with much lower percentages of gas.

Mr. Berkley: I have not tried it with such a large percentage.

Mr. W. C. Blackett said he thought the dangers of the lamp were exaggerated. He tried a Pieler lamp one day in a hot place in a pit, and could not get the flame of the lamp to lengthen when in pure air.

Mr. Brown said in an imperfect Pieler lamp the flame lengthened and began to show in fresh air conditions which were dangerous. He had tried the experiment many times with such an imperfect lamp, and every time it was used these dangerous conditions took place. The spirit boiled out and filled the gauze with the flame of burning alcohol.

Mr. Shaw: I have made some experiments with this lamp. I do not know what kind of spirits Mr. Brown used in the lamp, but it is possible that the hot flame is due to its not being pure spirits.

Mr. Brown: I do not know what kind it was.

Mr. Shaw: Was ordinary fire-damp or marsh gas used in the experiments recorded on page 181?

Mr. Brown: Ordinary mine fire-damp.

Mr. Shaw: The flames would have been less if pure marsh gas had been used.

Professor Merivale: Is there is any objection to using methylated spirits in a Pieler lamp?

Mr. Brown: None.

Mr. Steavenson said he had seen the lamp tried with the shield. They went into a place where gas was coming from the leader of a trouble, and the flame was so long that they were glad get out with the lamp. It was possible that the lamp described was an improved one, but it was dangerous. It was no doubt an exceedingly delicate test for gas; it showed the very smallest quantity, and showed it very well. The only difficulty in regard to it was that people wanted the indication made in safety.

Professor MERIVALE: There would be no difficulty in putting the lamp into a woollen bag, or case, or something of the kind, so as to extinguish it.

Mr. STEAVENSON: It blazes away a long time.

The PRESIDENT: It is an important desideratum to have a reliable indicator of gas; but if the indicator is unsafe itself we perhaps had better be without it.

Mr. J. D. WILSON: Has Mr. Brown tried this Pieler lamp in a place where gas has been found?

Mr. BROWN: Yes; but I would not go with it into a place where there was more than 2 per cent. of gas. I tried it in the lamp testing apparatus at Pelton collieries, in 4 per cent. of coal gas, and it fired immediately. I think if it could be measured, this lamp fires much quicker than the Davy lamp. The Davy lamp fires in about one second, and this lamp fires instantly. It is a most valuable lamp for the detection of less than 2 per cent. of gas, which can be affected with every safety.

Mr. BELL: You would use this lamp simply for finding out a very small quantity of gas, but where you know there is a larger quantity you would not consider this lamp safe?

Mr. BROWN: I would not.

The PRESIDENT: What would be the recommendation of this lamp—is its great advantage as a test?

Mr. BROWN: Yes. By its use you could judge, say in the main return, whether you are getting more gas at any time.

The PRESIDENT: But supposing, as Mr. Steavenson mentioned, you got more gas than you expected?

Mr. BROWN: I expect that Mr. Steavenson saw the flame from the boiling spirit. I tried to produce a similar flame before the meeting to-day, with this imperfect Pieler lamp, but it would not heat sufficiently to boil the spirit.

Mr. BLACKETT said an under-viewer at a colliery was absolutely certain that no one could show him any fire-damp in the pit with the lamp. He (Mr. Blackett) took the lamp into a place where there were 40,000 or 50,000 feet of air coming through, and they got with it a cap of three inches in the main return; and the under-viewer would scarcely believe that he saw the flame with his own eyes. The lamp was taken into a place where a hewer was working, and where with a Marsaut lamp no fire-damp could be seen. The Marsaut lamp was drawn down, and a mere pin head was seen, or the smallest margin of fire-damp; but with the Pieler lamp it

reached right up to the top of the gauze, and they had to retire and take the lamp out immediately. So that, where a man was working with a Marsaut lamp, the Pieler lamp showed the gas more distinctly than the Marsaut; and in the return, where the under-viewer considered that there was no fire-damp, the Pieler lamp showed that there was 1 or $1\frac{1}{4}$ per cent. of fire-damp. In the working place it showed over 2 per cent.

Mr. RAMSAY said it had often occurred to him that it might be desirable, when investigating for the presence of gas in mines, to use the spectrum. The Pieler lamp was evidently not a safe lamp to begin with. When they approached any explosive mixture, a naked light would be as safe as this lamp. Why not obtain a prism, a three-cornered piece of glass, and look through it, and find out the gas by the colour of its spectrum? Very small quantities of gas had been found by the spectrum.

Mr. WILLIS said the value of the Pieler lamp seemed to be that, in the normal condition of a mine, where it was known there was a certain percentage of gas—a very small quantity, perhaps, in the return, by occasionally testing it with the Pieler lamp they would see whether the percentage was increasing or decreasing. If it increased largely, they would expect a different state of things to the normal state; they would expect that either the ventilation was suddenly decreasing, or that the supply of gas was augmenting very rapidly. The Pieler lamp might be of use for regularly examining the returns, when they were certain that there was only a small percentage of gas, say from $\frac{1}{2}$ to 1 per cent. He did not see that it was of as much value as an ordinary testing lamp in workings; in fact, from the conversation that day, it seemed rather a dangerous lamp in unexperienced hands.

Mr. BELL: This lamp is simply another mode of testing the quantity of gas in mines, and different to that of Mr. Liveing. This is another form, and the question is whether it is safer.

The PRESIDENT: I should certainly be glad to pay the cost of any gentleman experimenting with this lamp, but after what I have heard to-day, I would rather not perform the experiment myself. Mr. Brown deserves our thanks for bringing this matter before the Institute, and I propose a vote of thanks to him.

Mr. RAMSAY seconded the vote of thanks, which was carried with acclamation.

# PROCEEDINGS.

## SPECIAL GENERAL MEETING, SATURDAY, JUNE 8TH, 1889, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

Mr. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The PRESIDENT said this special meeting had been convened for the purpose of considering the revised bye-laws, and any member could now draw attention to any particular law.

Mr. T. DOUGLAS said he wished to draw attention to the second paragraph in Bye-law No. 2, which was as follows:—

All Past-Presidents shall be *ex-officio* Members of the Council, so long as they continue Members or Associate Members of the Institute; and Vice-Presidents who have held office for three consecutive years shall be *ex-officio* Members of the Council so long as they continue Members or Associate Members of the Institute.

There was a little feeling that, under this rule, in the course of a few years there would be a large number of gentlemen who would be *ex-officio* Members of Council owing to their having for three consecutive years been Vice-Presidents. He did not wish to say anything in reference to this, further than that he thought the existing rule on the subject was considered by many to be better than the proposed new rule. He suggested whether it would not be better to adjourn the consideration of this rule to a future meeting, and in the meantime think the matter over.

Mr. J. G. WEEKS said he did not think he was telling any secret when he stated that the Council were not unanimous in regard to this rule; and he was obliged to Mr. Douglas for drawing attention to it. He believed, if the rule was retrospective that they would immediately get eleven Vice-Presidents added to the Council, in addition to those elected by members. If the rule was adopted, members must take care that Vice-Presidents were knocked off at the end of two years, and did not become eligible for the Council by three years' service as Vice-Presidents. He thought if the period of three years was extended to six years, it would prevent the Council from being flooded by Vice-Presidents.

The PRESIDENT said the number of Vice-Presidents who would join the Council would be nine, and not eleven as stated by Mr. Weeks. It so happened that out of all those who had been Vice-Presidents in the past thirty-seven years, there were now only nine gentlemen who would become *ex-officio* members of the Council under the new rule. The advantage to be gained by having this new rule, was that the Institute would not lose the services on the Council of gentlemen who had been Vice-Presidents for three consecutive years; and the Institute would have the advantage of all their experience, and would make room for new blood. There was some little difference of opinion in the Council as to the three years, but the majority decided in favour of it. He, himself, was strongly of opinion that it would be a great advantage to the Institute to keep gentlemen of experience on the Council. If it should be that there were any fears by Mr. Weeks or anybody else that *ex-officio* members of the Council would multiply too fast, then the members would have nothing to do but to act upon Mr. Weeks' suggestion and turn Vice-Presidents out at the end of the second year, and so prevent them from qualifying to become *ex-officio* members of Council. He moved that the new bye-laws be adopted, and that the necessary steps be taken to get them approved by the Secretary of State. Possibly the new laws might be in force by the time of the annual meeting in August.

Mr. M. WALTON BROWN said that the new bye-laws had only been in the hands of members a short time, whilst the Council had had the advantage of having had them for some months. It was true that there were now living only nine gentlemen who, as Vice-Presidents, would be entitled to become *ex-officio* members of Council under this rule; but had this rule been in operation from the earliest years, and gentlemen elected Vice-Presidents only for three years, it was highly probable that there would now have been at least thirty-four Vice-Presidents. One gentleman had been continually re-elected Vice-President since 1862, and if separate gentlemen had been elected after each three years the number of Vice-Presidents now eligible as *ex-officio* Members of Council would have been much greater. He suggested that the portion of bye-law No. 2 referring to Vice-Presidents be withdrawn, and No. 31 of the old bye-laws substituted for it.

Mr. WEEKS suggested, as an alternative to Mr. Brown's suggestion, that the term of three years in the new rule be increased to five years.

The PRESIDENT said the rules prevented any member being a Vice-President longer than three years consecutively. He thought the matter was in the hands of the members; they had nothing to do—not exactly to boycott them, but to elect Vice-Presidents for only two years, instead of three years. Presidents were elected for two years, although under the charter they could be elected for three years.

The SECRETARY pointed out that, to carry out Mr. Weeks' suggestion, rule 20 would have also to be altered.

Mr. J. B. SIMPSON: As this meeting is not a very large one, and as there seems to be a considerable difference of opinion about rule 2, could we not postpone the consideration of them?

The SECRETARY: It is extremely desirable, if they are to be passed, that they should be passed before the annual meeting in August.

Mr. SIMPSON: A good many members have not turned their attention to the rules, and it is their own fault. I confess I have not read the rules until to-day.

Mr. DOUGLAS said he would not have mentioned this matter but for the expression of opinion outside. In order to test the meeting, he moved, as an amendment, that the portion of the second paragraph of bye-law No. 2 relating to Vice-Presidents be not adopted, and that No. 31 of the old bye-laws be substituted for it.

Mr. WALTON BROWN seconded the amendment.

Mr. T. H. M. STRATTON seconded the motion proposed by the President. He said that it seemed to him that the difficulty had been somewhat exaggerated, because as a rule *ex-officio* Members of Council were not very regular in attending.

The amendment was carried by a large majority.

The PRESIDENT: I now move that the bye-laws, varied in accordance with the amendment, be adopted.

This motion was agreed to, and the special meeting concluded.

# PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 8TH, 1889, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

Mr. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting, and reported the proceedings of the Council.

The SECRETARY submitted the ballot list.

The following gentlemen were elected members:—

MEMBERS—

Mr. LANCELOT WILKINSON CHICKEN, Boldon Colliery.
Mr. FRANCIS COULTHARD, Arica Villa, Fox Houses, Whitehaven.
Mr. A. MAYON HENSHAW, Talk o' the Hill Collieries, Stoke-on-Trent.
Mr. THOMAS HALL, Aberaman Collieries, near Aberdare, South Wales.
Mr. HENRY WILLIAM HOLLIS, North Lodge, Darlington.
Mr. JAMES ROUTLEDGE JACQUES, Callio Villa, Whitehaven.
Mr. JOHN PLUMMER, H.M. Inspector of Mines, Bishop Auckland.

ASSOCIATE MEMBERS—

Mr. HUGH SIDNEY STREATFIELD, The Limes, Leigham Court Road, Streatham.
Mr. JOHN HENRY PROCTOR, 29, Side, Newcastle.

STUDENTS—

Mr. JOHN EVELYN CARR, Cowpen Colliery, Blyth, Northumberland.
Mr. EREDERICK WILLIAM HALL, Ryhope Colliery, Sunderland.
Mr. NORMAN SMITH, The Bank, Haydon Bridge.
Mr. JOHN WOOD, Coxhoe Hall, Coxhoe, R.S.O.

The following gentleman were nominated for election:—

MEMBERS—

Lieut.-Colonel JASPER GUSTAVUS SILVESTER DAVIES, R.E., Marton, Middlesbrough.
Mr. JAMES KENNETH GUTHRIE, Eltringham Colliery, Prudhoe, R.S.O.
Mr. JEREMIAH HEAD, Coatham, Redcar.
Mr. WILLIAM WALKER, Jun., H.M. Inspector of Mines, Durham.

ASSOCIATE MEMBERS—

Mr. T. C. HUTCHINSON, Hilda House, Middlesbrough.

Mr. ARTHUR PRANGLEY WILSON, 12, Barkston Mansions, South Kensington, London.

ASSOCIATE—

Mr. JOHN GEORGE GUY, Seaham Colliery, Sunderland.

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Mr. T. W. EMBLETON read the following "Notes of Reports on the Winning of the High Main Coal at Gosforth Colliery on the South Side of the Ninety-Fathom Dyke; and of the Winning of that Seam by Pits sunk on the South Side of the Dyke, and Drifting through that Dyke to Win the Coal on the North Side, with extracts from the various Reports relating thereto":—

# NOTES OF REPORTS ON THE WINNING OF THE HIGH MAIN COAL AT GOSFORTH COLLIERY ON THE SOUTH SIDE OF THE NINETY-FATHOM DYKE; AND OF THE WINNING OF THAT SEAM BY PITS SUNK ON THE SOUTH SIDE OF THE DYKE, AND DRIFTING THROUGH THAT DYKE TO WIN THE COAL ON THE NORTH SIDE, WITH EXTRACTS FROM THE VARIOUS REPORTS RELATING THERETO.

By T. W. EMBLETON.

14 Feby., 1740.

We, whose names are here underwritten, having taken a water-level from the Dean Pit in Gosforth Colliery, and finds y^t^ it runs about 60 yards to the west of the borehole at Salter's Bridge, and so will run on to Killingworth Moore for about 800 yards before y^t^ gets into North Gosforth grounds, and we are of opinion that there may be about 40 acres of ground in Gosforth y^t^ may have coal in it which may be about 1 yd. or 4 feet thick and about 40 fathoms depthness.

An Estimate of the Expence of Working Gosforth Colliery.

| | £ | s. | d. |
|---|---|---|---|
| Hewing per score ... ... ... ... ... ... | 0 | 2 | 0 |
| Putting ... ... ... ... .. ... ... | 0 | 1 | 0 |
| Abstract of other expences ... ... ... ... | 0 | 2 | 10 |
| | £0 | 5 | 10 |

Which, at 10 xx to the ten, will cost per ten, £2 18s. 4d.

The above is our opinions, as witness our hands.

Amos Barnes.
Edw. Smith.
Geo. Claughton.

It is presumed that, as no size of corf is mentioned, the corves were 16 pecks.

The report has no address, but I suppose it was given to one of the Brandling family.

14 March, 1753.

Expence of Working Gosforth Landsale Colliery with 11 Peck Corf.

| | £ | s. | d. |
|---|---|---|---|
| Hewing per score ... ... ... ... ... ... | 0 | 0 | 11 |
| Putting with odds ... ... ... ... ... ... | 0 | 1 | 0 |
| Other expences ... ... ... ... ... ... | 0 | 3 | 5½ |
| | 0 | 5 | 4½ |

| | £ | s. | d. |
|---|---|---|---|
| 16 scores to a tenn, working per tenn .. ... ... | 4 | 6 | 0 |
| 55 fothers to a tenn, to be sold at 2s. .. ... ... | 5 | 10 | 0 |
| Profit per tenn ... ... | 1 | 4 | 0 |

With 16 Peck Corf.

| | | | |
|---|---|---|---|
| Hewing per score ... ... ... ... .. ... | 0 | 1 | 6 |
| Putting ... ... ... ... ... ... | 0 | 1 | 0 |
| Other expences ... ... ... ... . . ... | 0 | 4 | 1½ |
| | 0 | 6 | 7½ |
| 11 scores to a tenn ... ... ... ... .. | 3 | 12 | 10½ |
| Coals sold, 55 fothers at 2s. ... ... ... ... | 5 | 10 | 0 |
| Profit per tenn ... ... | 1 | 17 | 1½ |

N.B.—Sinking and drifting, &c., are not brought into these estimates.

Jno. Watson.

View of Gosforth Colliery, 21 March, 1753.

I have viewed Gosforth Colliery, wherein there is only two pits to the rise of the drowned waste, viz.: the First and Fortune Pits. The First Pit is wrought out both, whole and walls. The Fortune Pit has wrought 260 tens of coals, and has a great quantity of whole coal yet left in her, which coal 200 yards to the north, 150 to the east, 180 to the south, and 120 to the west, has been tryed by drifts, and does not prove well. The carriages which come to buy the coal at the pit have many times refused it; and there has been many tryals made to burn it to cinders, but to no effect, for which reason I conclude that coal is not vendable.

J. Watson.

26 March, 1753.

We have this day viewed the Fortune Pit in Gosforth Colliery, and find at 10 yards east from the shaft a north headways drift 100 yards in. We tryed the coal at 30 yards in, and at the face of the drift. The coal at 30 yards brunt like charcoal, and that at the face much worse. There are no boards turned in this headways.

The ingate east[d] is 30 yds. from the shaft, and left in bad coal.

In fact, it is stated in the report in all the other parts of the pit "the coal brunt badly." In the south headways the whole coal is wrought away to the west as far as the First Pit thrust, and the walls we believe to be tollerable good, and may yield 100 tens of coal, including what may be vended along with them for a worse sort.

John Leaton.
Ra. Unthank.
*Jno. Watson.
Jno. Bell.

This report has no address.

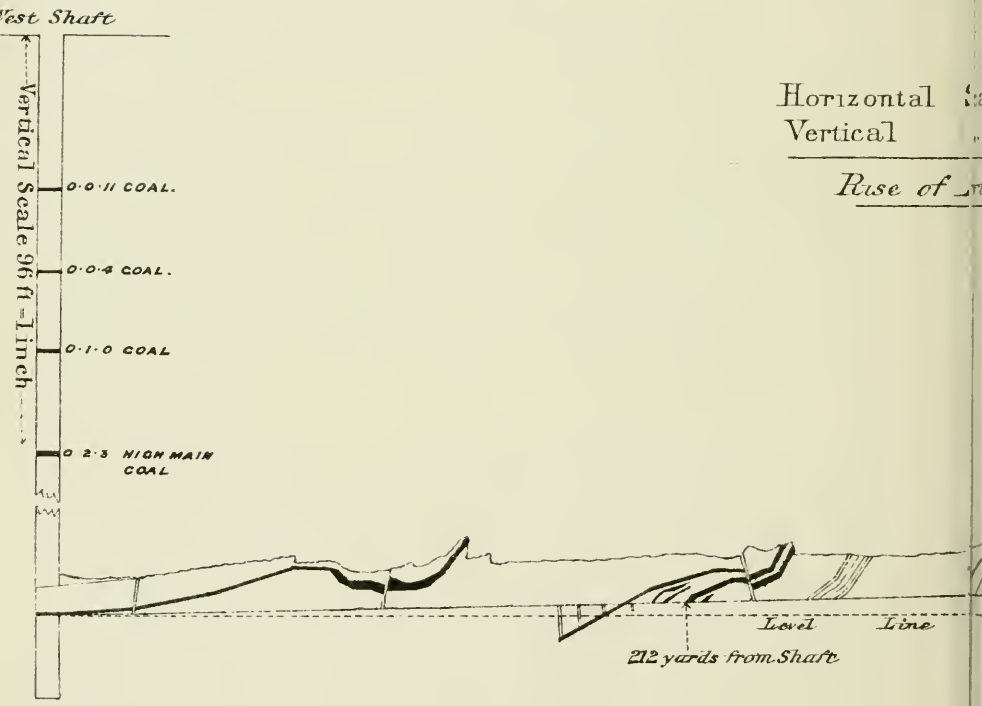
* This is not the Jno. Watson who made a report on the mode of mining the High Main on north side of the ninety-fathom Dyke. See report (page 193) of 19th Dec., 1816, and subsequent reports by him.

*To illustrate Mr. T. W. Embleton's "N*
*Main Coal, at Gosforth Colliery, on*

---

GOSFORTH COLLIER
*from the bottom of the West Shaft to*
*side of the Ninety Fathom Dyke.*

*1826*




Horizontal
Vertical

*Rise of*

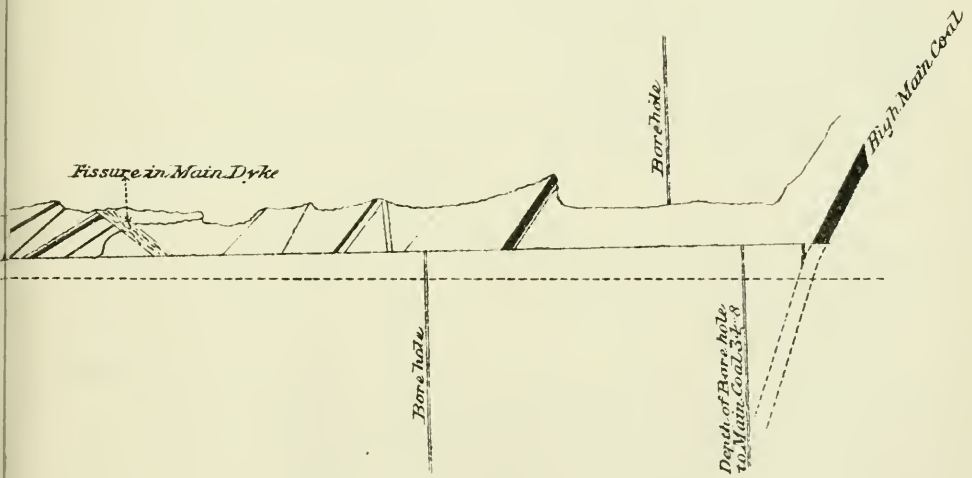
*...es of Reports of the Winning of the High ...oth sides of the Ninety-Fathom Dyke."*

---

*...* SECTION OF DRIFT.
*...ut the High Main Coal on the North ...rom original measurements made in ...nd 1829.*

...ale 192 feet to an inch
32 „ „ „

*...ift 1 in 228.*




Lambert & Co. Lp. Newcastle.

REPORT ON GOSFORTH COLLIERY, DATED WILLINGTON, 28 JANY., 1807, ADDRESSED TO JOHN BRANDLING, ESQ., MADE BY JNO. WATSON.

In reply to questions as to the quality and quantity of the High Main Coal in the Centre Pit and the coal that is lying between the two troubles west of the Quarry Pit shaft.

He states that there cannot be expected any considerable quantity of good coal to be found in this part of the colliery that can be vendable, owing to the coal being so intermixt with clay or other soft metal. He further says that his opinion is corroborated by several plans and views made as far back as 1753 (referring to the views of that date above written). "These views were made by persons who stood very high in the estimation of the world as professional men at that day."

To this report those estimates are appended, from which I extract the following particulars:—

No. 1.—ESTIMATE OF THE EXPENCE OF LAYING A SCORE OF 16 PECK CORVES OF COALS UPON BANK AT GOSFORTH COLLIERY UPON A VEND OF 10,000 FOTHERS YEARLY.

| | £ | s. | d. |
|---|---|---|---|
| Hewing per score with a 16 peck corf .. ... ... | 0 | 4 | 4 |
| Putting ... ... ... ... ... ... ... | 0 | 1 | 8 |
| Other expences ... ... ... ... ... ... | 0 | 18 | 2 |
| | £1 | 4 | 2 |

£1 4s. 2d. per score is equal to 4s. 10d. a fother.

There is a tract of 10¾ acres lying between the two troubles which I calculate will produce 58,695 fothers, which will supply, with the other consumption at the colliery, 10,000 fothers for about 4½ years. Selling price per fother 6s. 6d., cost 4s. 10d. Any fluctuation of vend or price of course will increase or decrease the profit.

No. 2.—ESTIMATE OF SINKING A NEW PIT TO COAL NOW DISCOVERED AT GOSFORTH COLLIERY LYING BETWEEN THE TWO DYKES WEST OF QUARRY PIT, JANUARY, 1807.

Sinking a pit 7 feet diameter 40 fathoms :—

13 faths, in clay at £4 ... .. ... ... ...
27 faths, in stone at £7 .. ... ... ... ...

The Quarry Pit will have to be sunk 4 fathoms to cut the coal on the dip side of trouble at £7 a fathom.

Driving stone drift (size not given) 30 yards at £2 ...
The total cost ... ... .. ... .. ...£686 0 0

No. 3.—EXPENCE OF WINNING THE COAL, BY WIDENING THE QUARRY PIT SHAFT, WHICH IS DISCOVERED BELOW THE DOWNCAST TROUBLE TO THE EAST OF THE QUARRY PIT SHAFT, GOSFORTH COLLIERY, JANUARY, 1807.

| | | | |
|---|---|---|---|
| Widening the pit from 5 to 7 feet, 30 fathoms at £2 10s, | | | |
| Sinking from present bottom of shaft to level of coal below trouble, 4 fathoms at £7 0s. 0d. ... ... | | | |
| Stone drift, 30 yards at £3 0s. 0d. ... ... ... | | | |
| Total cost ... ... | £406 | 0 | 0 |
| In favour of winning the coal by the Quarry Pit ... | 280 | 0 | 0 |

ESTIMATE OF WINNING NORTH GOSFORTH COLLIERY, FEBRUARY, 1806.

ASSUMED DATA.

1st. The depth of the Engine Pit to High Main Coal, 120 fathoms.
2nd. Time of effecting the winning to the delivery of coals, 3 years.
The particulars are in round sums amounting to £44,000.
There is an item of £1,000 for a bridge across the Ewes Burn.
Place of winning not stated.

| | £ | s. | d. |
|---|---|---|---|
| First year's outlay ... ... ... ... ... | 15,100 | 0 | 0 |
| Second ,, ... ... ... ... ... | 750 | 0 | 0 |
| Third ,, ... ... ... ... ... | 21,400 | 0 | 0 |
| | £37,250 | 0 | 0 |

This estimate bears no signature, but was probably made by Mr. T. King in Nov. 1816.

ESTIMATE OF THE EXPENCE OF WORKING GOSFORTH COLLIERY ON A VEND OF 8,000 CHALDRONS PER ANNUM, SUPPOSING THE COALS TO BE DELIVERED BY WAGGONS AT THE BARRAS BRIDGE.

| | £ | s. | d. |
|---|---|---|---|
| Hewing per score, 16 peck corves ... ... ... | 0 | 3 | 3 |
| Putting ... ... ... ... ... ... ... | 0 | 2 | 6 |
| Other expences ... ... ... .. ... ... | 0 | 10 | 8 |
| Total expence of laying coals on bank ... ... | 0 | 16 | 5 |

| | £ | s. | d. |
|---|---|---|---|
| Or per leading chaldron ... ... ... ... | 0 | 9 | 10 |
| Other expences, including wayleave rent, interest of capital, and cost of railway ... ... ... | 0 | 2 | 2 |
| Total expence of delivering the coals at the Barras Bridge ... ... ... ... ... ... ... | 0 | 12 | 0 |

| Amount of sales— | | | |
|---|---|---|---|
| 8,000 chas. of coals at 22s. 6d. ... ... | £9,000 | 0 | 0 |
| 8,000 chas. will cost working at 12s. ... ... | 4,800 | 0 | 0 |
| Annual gain ... ... ... | £4,200 | 0 | 0 |

Total expectation from the High Main Coal Seam on the south side of the Great Dyke, 12¼ years.

It may be also necessary to remark that the consumption of Newcastle and its environs amounts to (at a moderate computation) 33,000 chaldrons, consequently if the Gosforth Coal could be laid immediately in the vicinity of the Town, its quality being much courted by private families, I have no hesitation in saying that the data for the annual vend to be 8,000 chaldrons is comparatively small, taking into consideration the idea of having a depôt so near so populous a Town in severe weather, when it is known that the communication by the Tyne in winter is suddenly and frequently cut off. JNO. STRAKER.

Felling Office, 2 June, 1810.

At this time it began to be seriously contemplated to win the Gosforth Coal on the north side of the dyke, by sinking on the south side and drifting through the dyke.

GOSFORTH WINNING, 1816.

ESTIMATED EXPENCE OF WINNING THE HIGH MAIN COAL IN GOSFORTH ESTATE, LAYING NORTH OF THE GREAT DOWNCAST DYKE OF 90 FATHOMS. BY SINKING ON THE SOUTH SIDE IT IS PRESUMED A PUMPING ENGINE MAY NOT BE NECESSARY.

Diameter of pit 12½ feet, and depth 128 fathoms.

| | |
|---|---|
| Total cost without pumping engine ... ... ... | £24,000 |
| Addition with a pumping engine ... ... ... | 12,000 |
| Total ... ... ... ... | £36,000 |
| Time of winning without engine ... ... ... | 1¾ years. |
| ,, ,, with ,, ... ... ... | 1¼ ,, |
| Total ... ... ... ... ... | 3 ,, |

The sinking per fathom, including timber and deals, powder, candles, nails, and labourage, 128 fms., at £44.

Stone-drift through the dyke, £1,000. No distance or price given.

Extra cost with pumping engine—

Increased labourage in sinking, £30 per fathom.

Also 20 fathoms tubbing at £120.

| | Without Engine. £ s. d. | | With Engine. £ s. d. |
|---|---|---|---|
| To be spent first year ... | 7,966 0 0 | ... | 13,124 0 0 |
| ,, second year ... | 16,034 0 0 | ... | 5,424 0 0 |
| ,, third year ... | — | .. | 17,452 0 0 |
| Totals ... | £24,000 0 0 | ... | £36,000 0 0 |

The preceding estimates, I am firmly of opinion, are amply sufficient to effect permanently the winning of Gosforth, as liberal allowances have been made in the various calculations.

Nest House, 28 Nov., 1816. THOMAS KING.

Mr. King makes request to Mr. John Watson to advise the most advisable situation to sink to win the Gosforth Coal on the south side of the dyke. A plan is submitted for his information, and suggests that a pumping engine may not be required, to state as to the advisability of winning the coal on the north side of the dyke, and the probable expence of such a proceeding, with the advantage likely to be derived by saving the expence attendant of a sinking engine.

Nest House, 3 Dec., 1816. THOMAS KING.

MR. JOHN WATSON'S REPORT, WILLINGTON, 19 DEC., 1816.

Mr. Watson replies very cautiously. He writes—

As it must be allowed that any estimate formed of the expence of completing undertakings of so precarious a nature as that of winning coal mines must ever be liable to be disturbed, as many unforseen difficulties occur in the prosecution that

no human being could possibly forsee, and of course inevitably create additional expence, hence the estimated expence of completing such like undertakings have very frequently fallen short of the real expenditure, therefore under such circumstances every allowance should be made.

But he adds—

I have endeavoured to form my estimate upon such grounds as, I trust, no great difference will arise between the sum I have calculated this winning to cost and the real expenditure.

The estimate is based upon a supposition that 40,000 chaldrons of coal are to be wrought and vended annually, and that the coals are to be led down the Kenton and Coxlodge waggon-way, as far as circumstances will admit.

As to sinking, whether on the north or south side of the dyke, it does not admit of a doubt in my mind that sinking the pit on the south side of the dyke, and drifting through the same till it cut the coal on the north side, is the most eligible mode.

It will give an opportunity of exploring the lower seams under the south part of Gosforth Estate. There is every probability that little or no water will be met with in sinking—at least not more than the machine which is proposed to be put up for the purpose of drawing the coals after the colliery is won is capable of pumping. On the north side of the dyke, water will be met with, as had to be contended with at the adjoining collieries of Coxlodge and Killingworth; but on the south side there will not only be a considerable sum of money saved in the sinking expence, but the winning will be accomplished in a shorter time. If the water should be found troublesome it might be delivered into the High Main Coal waste, where it will serve away, and will take off the lift of a column of water of 38 fathoms in height.

He considers—

Although no pumping engine will be required during the sinking, y$^{t}$ one will be required to pump the colliery feeders that will issue from such an extensive field of coal lying under the Gosforth Estate and the other estates contiguous thereto.

Taking all the circumstances combined in this extensive undertaking into full consideration, it appears to me it will cost about £35,200, including 140 double workmen's houses, with stables, offices, and a staith to contain about 3,000 chaldrons of coal.

The situation of the winning is most judicially fixed, as it appears the High Main Coal Seam there is entirely whole and strata solid.

The exact situation of dyke to be ascertained by driving the north headways from the coal pit near the Kenton waggon-way bridge till it reaches the dyke.

Recommends a bore hole on north side of dyke to some known strata, and thus ascertain the depth of the High Main Coal before setting away the drifts.

The shaft to have three divisions made by brattices—one division for drawing coals from the drift, the second for drawing coals from south of the dyke, and the third for pumping.

The Beaumont Seam will be 130 fathoms from the surface, and I recommend that seam should be used for standage by sinking a few yards below the drift.

JOHN WATSON.

To Mr. Thomas King.

To sink on south side of dyke 128 fathoms, drift water level, 100 yds. through the fissure of the dyke. Sinking will not require a fire engine. Estimate £17,826

0s. 0d., and will be completed in one year. To make the winning with fire engine, £18,536 0s. 0d. ; time, 2 years. From these considerations, therefore, I w^d recommend the winning to be made on the south of the dyke where marked upon the plan, as the pit will be sunk on a tract of whole coal, which will secure the shaft from water and other casualties.

Killingworth Colliery, 21 Dec., 1816. RALPH DODDS.

Messrs. Watson and Hill, at the request of Mr. W. Brandling, reported on the different modes by which a winning of the High Main Coal in Gosforth Estate may be accomplished.

First—The most effectual would be to sink near to the east boundary in a situation about midway between the great dyke to the south and the north boundary of the estate. A pit here would lay dry all the coal in Gosforth, but the immense depth, nearly 200 fathoms, appears to us to put all idea of a winning in that situation entirely out of the question, at least in the present day.

Another means is to sink a pit, in Brunton or Gosforth, upon the line of the Coxlodge water levels, and continuing the pit below the Main Coal, and extending a stone drift horizontally to the east until it intersects the coal. A pumping engine of considerable power must be placed in Brunton or Gosforth besides other steam engines for drawing coals.

A third method : to sink at a place about 130 or 160 yards to the east of Low Gosforth. Here the coal is calculated to lie at about 160 fathoms. Here the coal might be wrought to the north and south of the pit, and the expence of any future winning avoided.

The fourth is to place the winning near the great dyke, but on the south or upper side thereof. This mode of winning we judge to be the most favourable of the whole. As to the first, second, and third methods, though more coal will be obtained, we think that a pit sunk here might be carried to its destination without the assistance of an engine ; that the quantity of water, we are persuaded, will not embarrass the sinking in a material degree, but this would not be the case if the pit was sunk on the north side, be the situation where it might. This sinking on south side of dyke would explore the various seams below the High Main Coal, and also a quantity of coal in Killingworth which is not likely to be worked at that colliery. Another advantage is the proximity of the pit to the Coxlodge wagon way.

We propose to sink two pits, one 12 feet diameter, and the other 8 feet, or at most 8½ feet, the former to be divided into two parts, one part for pumping and the other for drawing coals, the latter exclusively for coals.

Both pits to be carried down 150 fathoms, when, or little below, the Denton Low Low Main, about 3 feet thick will be met with, where standage may be made with advantage. A pair of drifts to be set away in a northerly direction passing through the great and 10 fathom dykes until they intersect the coal on the north side of these dykes. We propose to limit the depth of the pits to 150 fathoms, because we consider that a sufficient depth from which to draw either coals or water. According to our calculations the drifts will meet with the Main Coal Seam at 569 yards from the pits, unless the coal should be thrown further up to the south than what we suppose by what we have called the 10 fathom dyke, and in this case the coal will be sooner got. The drifts to be driven exactly opposite the full dip of strata. We calculate the quantity of coal to be obtained 450 acres, and, as the seam is 4 feet, we reckon that 1,200 chaldrons of merchantable coal will be obtained

from an acre ; but, if the lower water levels of Coxlodge Colliery will reach, the 450 acres will be reduced to 350, and the merchantable coal to 420,000 chaldrons.

We estimate that without the help of a pumping engine the outlay will be £39,287, exclusive of rent. If with an engine, this sum will be increased to £49,787. If the coal is obtained without an engine, there will be a saving of £2,677 during the sinking, and the whole expence will amount to £47,110.

We estimate the time to be 4 years at the utmost.

John Watson.

19 Jany., 1824. Geo. Hill.

Detailed estimates are given.

Letter Addressed to Messrs. Watson and Straker, by Mr. Geo. Hill.

Coxlodge Colliery, 10 Nov., 1826.

He states that—

The Pits are very near the Beaumont Seam, and asks if drifts are to be set away on reaching that seam in order to explore the mine towards the great dyke, in order to ascertain the situation and size of the dyke, and also to decide upon the depth to which the pits should be sunk before setting away the drifts. The pits have reached 124 fathoms. Quantity of water, 8 gallons a minute, and no increase for the last 50 fathoms.

The Denton Low Low Main will be found at about 20 fathoms below the Beaumont Seam. State, if no preliminary trials are necessary, the depth at which the sinking should be discontinued.

Geo. Hill.

Report, 10 Nov., 1826.

No approach to the main dyke by drifting should be made, because collateral dykes and water may be found, and also a profusion of water in cutting the main dyke at so high a level. We think that the High Main Coal on the north side of the dyke will lie at the depth of 200 fathoms ; but as an upcast dyke is known to exist at the distance of 300 yards still further north, this may reduce the depth to 180 fathoms. Pits to be continued to depth of 180 fathoms, and then the drifts may be commenced with safety, and that they may probably cut the coal near the 10 fathom dyke.

The great object to be aimed at is that the drifts on reaching the dyke should not be more than 10 or 12 fathoms above the coal. Should they be much above that level there is danger of water, and thus the prudent precautions already taken by sinking on the south side of dyke would be rendered abortive.

John Watson.

John Straker.

How could this fact be ascertained before driving of drift from the imperfect data then known ? The upcast dyke of 10 fathoms, mentioned in the above report, was not met with in the stone drifts, or in pursuing the High Main Coal when cut. It has no existence north of the main dyke at Gosforth.

Coxlodge Colliery, 13 Aug., 1827.

To Messrs. Watson and Straker.

Since the 10 Nov. last, the date of your report, the pits have arrived at the depth at which you recommended the drifts to be commenced. To consider whether it is still advisable to set away the drifts at the depth you mentioned. The number and size of the drifts, taking into account that the ventilation should be sufficient for the different districts of the mine. Consider the course of the drift. State the length of the drifts and the time which will be occupied in driving them. Can the erection of the pumping engine be deferred till the coal is cut; if not, at what stage of the drifting should such an engine be erected?

For the Owners of Gosforth Colliery,
GEO. HILL.

REPORT, 13 AUG., 1827.

The depths at which the drifts should be set away, we have made no change of opinion, viz., 180 fathoms. There should be two drifts of 60 square feet clear; size generally 7 feet high by 9 feet wide.

The course of the drifts should be due north, or at right angles to the dyke. Uncertainty as to distance of drifts, they will not exceed 600 yards; the time, 150 weeks; the expence, £9,350, or say £10,000 including everything. Pumping. engine ought to commence next spring, and should be erected before the drifts cut the main dyke, which is the first place where any water may be dreaded.

JNO. WATSON.
JNO. STRAKER.

The report of 19th January, 1824, advising that the two shafts should be sunk to a depth of 150 fathoms was adopted, and on the 24th March, 1825, the ground for the West Pit was thrown out, and that for the East Pit on the 2nd May following. On the 10th November, 1826, Mr. Hill addressed a letter to Messrs. Watson and Straker, stating that the shafts are very near the Beaumont Seam, and asks if the drifts are to be set away on reaching that seam, in order to explore the mine, and in order to ascertain the situation and size of the dyke, and to decide upon the depth of the shafts and other particulars, as in the above letter.

Messrs. Watson and Straker, on 10th November, 1826, reply that the High Main Coal on the north side of the dyke will lie at the depth of 200 fathoms, and mention the existence of an upcast 10 fathoms dyke at 300 yards. This will reduce the depth to 180 fathoms, and recommend the shafts to be sunk 180 fathoms.

On 13th August, 1827, Mr. Hill stated that since the report by Messrs. Watson and Straker, the shafts had reached 180 fathoms, and asks these gentlemen to state the probable length of the drifts and the time occupied in driving them, and other matters.

On the same day, Messrs. Watson and Straker state the depth of 180 fathoms is enough, the two drifts to be each 7 feet high and

9 feet wide. The distance will not exceed 600 yards—time, 150 weeks; the expense £9,350, or, say, £10,000.

The West Pit was sunk to the depth of 181 fathoms 0 feet 2 inches, and the East Pit 181 fathoms 2 feet 9 inches, and the West Pit drift was set away at 1 p.m. on 23rd August, 1827, and reached the High Main Coal at 10 a.m. on 31st January, 1829. A hole was bored 1 foot 6 inches into the post, and at 2 p.m. a piece of the coal was sent up to Mr. Hill at Kenton, and a corf of coal was sent to the Rev. R. H. Brandling at Gosforth. On Monday, 2nd February the coal was found in regular course 5 feet 6 inches thick, all clean coal, rising at the rate of $9\frac{3}{4}$ inches to the yard, and, of course, there was a celebration of the auspicious event on that day, followed by the celebrated underground ball on the 6th February.

The distance of the west drift from the lip of the West Pit was 584 yards.

On 11th February Mr. R. W. Brandling, and on 20th February the Rev. R. H. Brandling, accompanied by Dr. Headlam, descended the shaft.

On Saturday, 28th February, the first cargo was shipped for the London market in the *Penelope* of $10\frac{1}{2}$ keels.

On Friday, 20th March, 25 hewers, 20 putters, 3 half marrows, were bound.

On 8th April, the men were set on by the score, being paid 4s. 6d. a score for round, and 2s. for small. Corf, 20 pecks.

On the 23rd August, 1828, the west drift reached the distance of 440 yards, being at the average rate of $8\frac{1}{2}$ yards per week. The greatest rate was in the fortnight ending 25th March, 1828, 29 yards; and the least in the fortnight ending 15th June, 7 yards. On 30th August the east drift was driven 443 yards, average rate also $8\frac{1}{2}$ yards. Pay ending 8th April, 1828, the rate was 27 yards, and the least in pay ending 15th January, 7 yards.

Mr. S. C. Crone has kindly sent me an extract from Mr. Hill's memoranda stating that the west drift was begun 23rd August, 1827, and was finished 11th February, 1829, being a period of 77 weeks; average progress, $7\frac{1}{2}$ yards a week; cost, £1,516.

The east drift begun 30th August, 1827, and finished 22nd July, 1829; time, $77\frac{1}{3}$ weeks; average, $7\frac{3}{4}$ yards per week; cost, £1,541 19s. 0d.

The bargains let to the men driving the west drift and the east drift, were as follows:—

| WEST DRIFT. | | | EAST DRIFT. | | |
|---|---|---|---|---|---|
| No. of Bargains. | No. of Yards in each. | Prices per Yard. | No. of Bargains. | No. of Yards in each. | Prices per Yard. |
| 1 | 20 | 26s. | 1 | 20 | 28s. |
| 2 | 30 | 30s. | 2 | 30 | 30s. |
| 3 | 50 | 40s. | 3 | 50 | 40s. |
| 4 | 50 | 50s. | 4 | 50 | 50s. |
| 5 | 10 | 80s. | 5 | 10 | 80s. |
| 6 | 31 | 80s. | 6 | 31 | 80s. |
| 7 | 50 | 46s. | 7 | 5 | 65s. |
| 8 | 50 | 46s. | 8 | 45 | 46s. |
| 9 | 168 | 45s. | 9 | 50 | 46s. |
| 10 | 27 | 30s. | 10 | 177 | 45s. |
| 11 | 14 | 60s. | 11 | 24 | 30s. |
| 12 | 85 | 84s. | 12 | 16 | 60s. |
| 13 | 10 | 17s. | 13 | 85 | 84s. |
| | | | 14 | 7 | 17s. |
| | Total 595 | | | Total 600 | |

With regard to the actual size of the fault, it would appear to be considerably more than 90 fathoms, if we assume the depth of the coal towards the fault as found on reaching the High Main Coal, and the same inclination of the fault as shown on the section. (Plate XXIV.).

I calculate the throw of the dyke to be 157 or 158 fathoms, viz.:—

| | | |
|---|---|---|
| Depth of the shaft ... ... ... | 181 | fathoms. |
| The old waste of the High Main Coal on south side of fault was found at | 35 | ,, |
| | 146 | ,, |
| Assuming, as above, the intersection of the line of the dip of the coal and the angle of the fault, the coal at this point lies 11 fathoms below the thill of the drift ... ... ... | 11 | ,, |
| Extent of dislocation ... | 157 | ,, |

The 10 fathom dyke spoken of in the reports was not found in the drift or in the coal beyond. There was no disturbance of the strata on either side of the fault. Both the north and south sides of the fault were comparatively smooth, and had the appearance of a clear fracture. The space between the two sides was filled up with broken shale and sandstone, and in the middle was seen the curiously-shaped sandstone (see Plate XXIV.) Neither gas nor water was met with. The coal itself merely afforded a "bleeding."

The temperature of the coal was 64 degs. Fahr. I had a cavity cut in the coal about a yard cube, walled in front, with a small door, through which a thermometer could be placed and withdrawn for reading. This was near the place where the coal was cut (a few yards north of it, at the end of the first east board).

Mr. Crone has kindly sent the following record of temperatures taken :—

| 31 Oct., 1827. | Degrees. |
|---|---|
| Temp. of air at the surface ... ... ... ... ... ... | 43½ |
| Do. within 7 fathoms of the main drift in the West Pit ... | 54 |
| Do. at face of main drift, West Pit ... ... ... ... | 57 |
| Do. in stenton near the shaft .. ... ... ... ... | 57 |
| Do. at face of main drift, East Pit ... ... ... ... | 59½ |
| Do. water discharged from hoggar in East Pit at bottom ... | 56 |
| Do. air in East Pit, a few fathoms above the main drift ... | 58 |
| 16 Nov., 1829. | |
| Temp. of air at the surface ... ... ... ... ... ... | 39 |
| Do. at bottom of East Pit ... ... ... ... ... | 49 |
| Do. in west main drift to the north of the stables ... ... | 67 |
| 20 Nov., 1829. | |
| Temp. of air at the surface in the shade ... ... ... ... | 30 |
| Do. at bottom of East Pit ... ... ... ... ... | 46 |
| Do. in west main drift to the north of the stables ... ... | 66 |
| 19 Dec., 1829. | |
| Temp. of air at the surface ... ... ... ... ... ... | 33 |
| Do. near bottom of East Pit ... .. ... ... ... | 47 |
| Do. at bottom of West Pit, north of stable board ... ... | 64 |
| Do. at bottom of West Pit ... ... ... .. ... | 68½ |
| Do. water in horse cistern at bottom of West Pit ... .. | 55 |
| Wind north, with sleet and snow. | |

In conclusion, as the working of the coal proceeded to the north the rise of the coal decreased and became comparatively level, and it is extremely probable that if the section of the coal seam had been continued to this point, that this point would have been nearly level with the High Main Coal on the south side of the fault, thus showing that the subsidence of the strata was on the north side.

The PRESIDENT said they were very much obliged to Mr. Embleton for bringing before them such interesting facts and statistics.

Mr. J. B. SIMPSON said he did not know anything about the Gosforth neighbourhood. He had put through the Ninety-fathom Dyke in one part of the county, and found it to be 157 fathoms; and he understood that in some parts it was 220 or 200 fathoms. Perhaps Mr. Crone could give them some more information upon this matter in his neighbourhood, and if he would give sections down to the Dyke they would be of interest. Mr. Embleton stated that it rose 9 inches in the yard. At Backworth Colliery, near the Dyke, the dip was 12 to 13 inches; and he believed at Backworth the throw of the dyke was as much as 190 fathoms; and this made the fault more than it was at Gosforth. Coming westward he had put through the hitch at Stella Colliery, and it was only 70 fathoms. It appeared to be less as it went westward, and to be larger as it went eastward. He proposed a vote of thanks to Mr. Embleton for his interesting paper.

Mr. S. C. CRONE said he had very great pleasure in seconding the vote of thanks to Mr. Embleton, who had been intimately associated with the formation of the drift he had described, which was a very important matter in the days when it was done, and would have been considered a very important one now; for it was rather a difficult ordeal driving so long a drift through what might be called "the dead Coal Measures." He supposed that it would be calculated that the fracture would be something like ninety fathoms, and so it was called by that name. The appellation Ninety-fathom Dyke was altogether a misnomer. He had no doubt it had been called the Ninety-fathom Dyke in consequence of its having been proved to have about that amount of dislocation farther westward. The probability was that the original drift was designed to cut the seam at the down throw of ninety fathoms. The seam certainly rose in a very rapid manner, and then, by the projection of the drift forward, they would cut the seam in as perfect a state as could have been expected. They worked nearly all the rise coal, and there was nothing but the dip coal left to work later.

Mr. SIMPSON: You do not expect they would take the dip coal first, and leave the rise?

Mr. CRONE continuing, said that in his day the workings were below the level of the drift, and followed the dip of the seam,

and then worked back again. It dipped considerably, as the rise was on the line of the drift. He was determined to prove the dyke in the dip line of the seam, and they went downwards until they cut it. By this means he proved beyond a doubt that the full fracture amounted to 175 fathoms. No doubt it was the side of the dyke and the leader was about 3 feet thick; it was formed of débris of rock filled up with loose matter, and they seemed to be waterworn, or as if they had been ground and abraded or rounded off. He was certain it was the dyke, and he was very glad to be able to prove that the amount of the fracture was 175 fathoms. As Mr. Simpson said, it seemed to decrease as it went westward; but he did not know that it increased very much as it went eastward. He had no proof at Killingworth as to what the amount of the fracture might be there; but as it was at no great distance from the point where he proved it at Gosforth Colliery, he did not anticipate that there was very much difference between Killingworth and the place at Gosforth where it was 175 fathoms. He was glad that Mr. Embleton, who was present when the work was done, had read this paper. He (Mr. Crone) had Mr. Hill's diary, which he had found among the colliery books; there were several volumes of a very interesting character indeed; the records had been very carefully kept, and were most interesting.

Mr. Simpson asked what the angle of the hade of the fault was.

Mr. Embleton: I do not remember now. If I had my memorandum-book I could tell you.

Mr. T. H. M. Stratton said that Mr. Embleton's paper was a very interesting one from many points of view. The statements of the cost of working coal one hundred years ago was very interesting. After he came to Cramlington Colliery he came across an old book containing the contracts compiled from the Old Plessy Pit of Sir Matthew Ridley, and the cost of working them under very similar conditions was about 1s. 3d. a ton into waggons. He dared say a great many of them would be glad to see that day again. He was very much struck with the hade of the leader, because they had always noticed that the bigger the dyke the more perpendicular it was. At Seaham the leader of a large trouble was absolutely perpendicular; the sides were about 4 feet apart, and the two walls were closely defined, as if a person had taken a chisel and chiselled down between the two faces.

Mr. EMBLETON: Is the fracture there between the hard rock?

Mr. STRATTON: It was post.

Mr. EMBLETON: The inclination of the fault varies with the hardness of the strata; if the strata are soft the fault inclines, and if hard the fault is more perpendicular.

The SECRETARY (Professor G. A. Lebour) said there were two points he should like a little information about from Mr. Embleton; one was whether he had any record of the manner in which the temperature-observations were made, what instruments were used, and whether any precautions were taken, so that the temperature should be from the rock at certain depths, instead of the air in the workings. The other matter was that Mr. Embleton pointed out how little disturbance there was in the seams close to the fault. It struck him (the Secretary) that the smaller dislocations were really a portion of the disturbances on approaching the dyke; and that it was because the fault was such a very big one that the disturbances approaching it were so very large. He did not know whether he was right. He agreed with Mr. Embleton as to the change in the hade being according to the hardness of the beds; there was usually a vertical hade in hard rock, and inclined in the soft rock.

The vote of thanks was agreed to.

Mr. EMBLETON said he was very much obliged for the vote of thanks.

The PRESIDENT: The further discussion of the paper was then adjourned, until the paper was printed and in the hands of the members.

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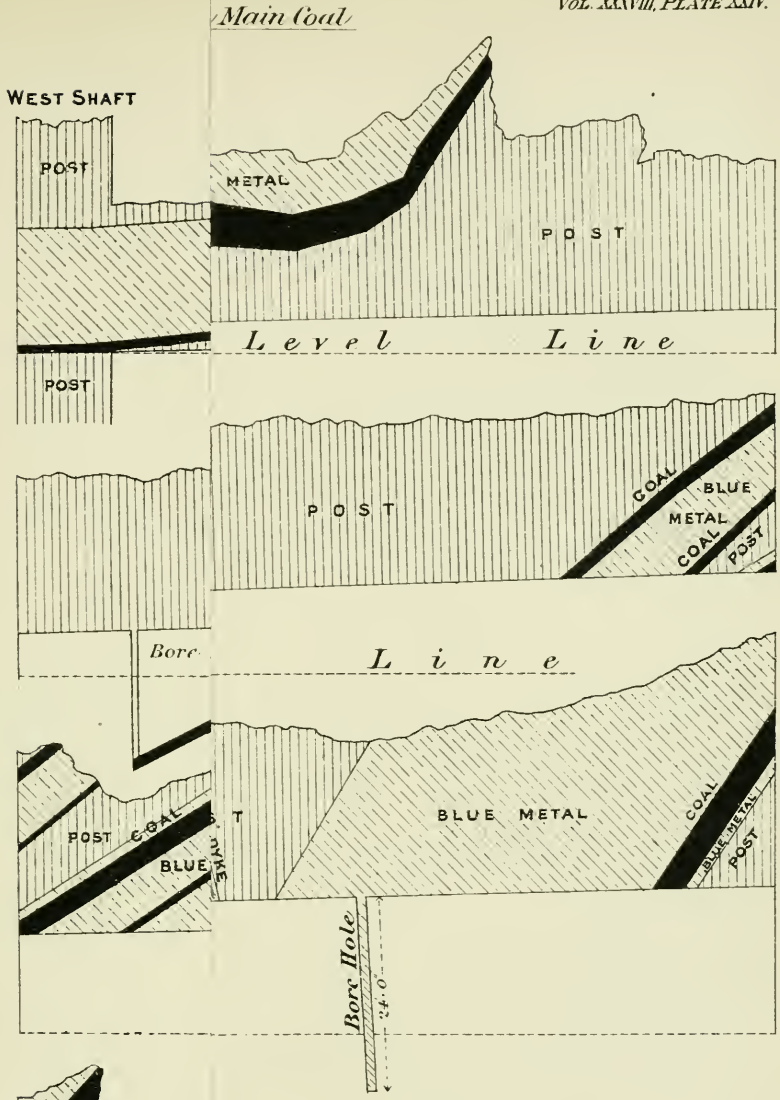
Mr. T. L. ELWEN read the following paper on "An Account of Experiments on the Resistance to Air Currents in Mines":—




## GOSFORTH COLLIERY.

### SECTION OF DRIFT,

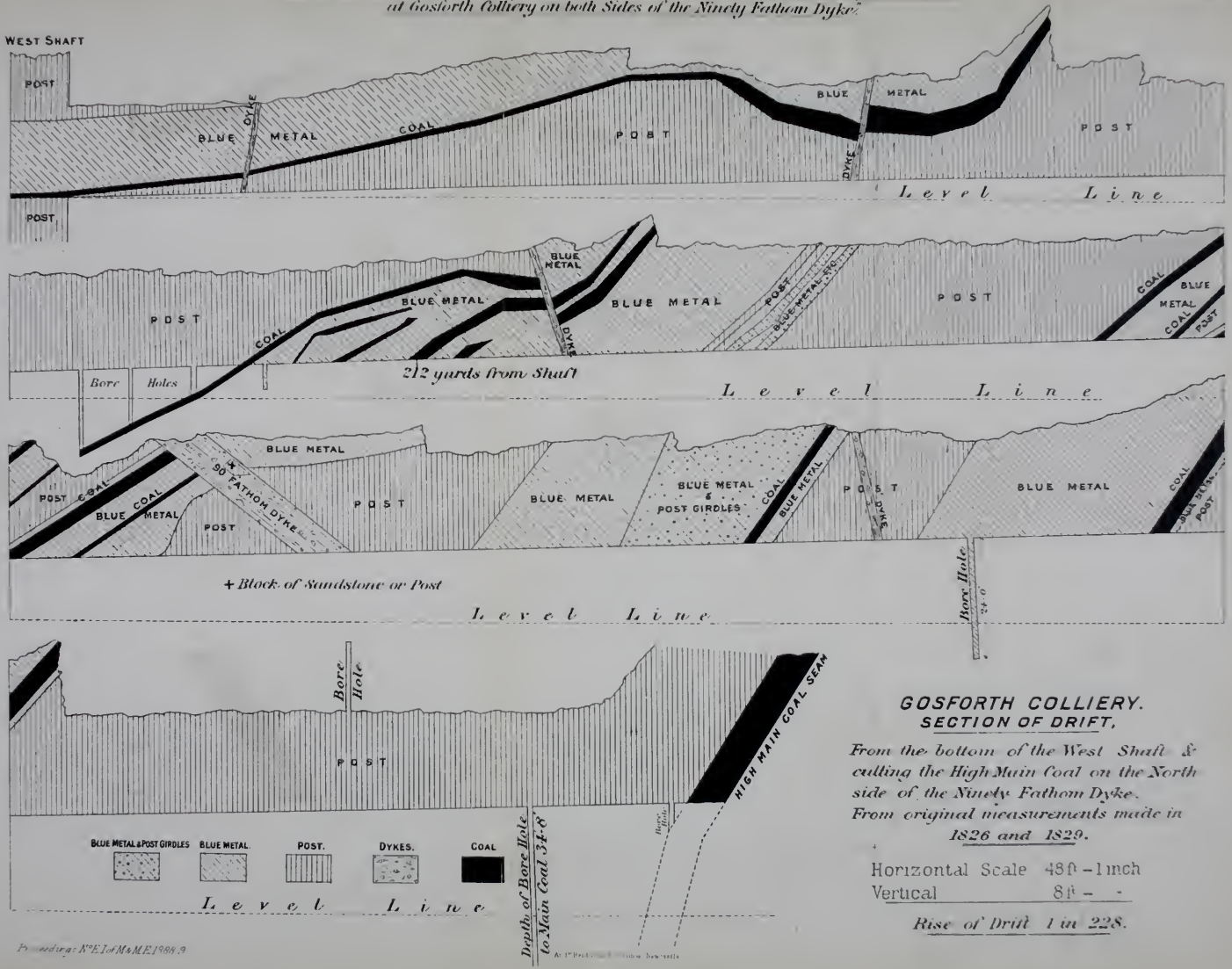
*m the bottom of the West Shaft & ting the High Main Coal on the North le of the Ninety Fathom Dyke. m original measurements made in 1826 and 1829.*

BLUE MET.

Horizontal Scale 48 ft – 1 inch
Vertical 8 ft – "

*Rise of Drift 1 in 228.*

*To illustrate Mr T W Embletons "Notes of Reports on the Winning of the High Main Coal at Gosforth Colliery on both Sides of the Ninety Fathom Dyke"*




## GOSFORTH COLLIERY.
### SECTION OF DRIFT,

*From the bottom of the West Shaft & cutting the High Main Coal on the North side of the Ninety Fathom Dyke. From original measurements made in 1826 and 1829.*

Horizontal Scale 48ft – 1 inch
Vertical 8ft – "

*Rise of Drift 1 in 228.*

Proceedings N°E.I. of M & M.E. 1884-9

# AN ACCOUNT OF EXPERIMENTS ON THE RESISTANCE TO AIR CURRENTS IN MINES.

By T. L. ELWEN.

THE object in entering upon these experiments arose in consequence of the unsatisfactory state of the results arrived at when calculating the power required to overcome the resistance to air currents in mines by means of the ordinarily accepted formula.

The experiments recorded have been selected from a large number which gave about the same results under similar conditions, and which will, it is trusted, receive favourable consideration.

The instruments used in making these experiments were:—(1) A portable aneroid barometer of large size, reading by means of a vernier and lens, an altitude of one foot, which is equal to a difference of pressure of 0·076 lbs. per square foot. (2) A water-gauge, 4 inches square by 6 inches high, whose large surface of water column, reduced proportionately the amount of capillarity, and presented a more level surface. Levels were attached to the gauge. The scale was graduated from the centre, and divided into 20ths of an inch, and by means of a vernier and lens, reading by calculation to the 200th part of an inch. Thus, supposing two readings to be 1·05 inches and 1·00 inches, the mean (1·05 + 1·00 ÷ 2=) 1·025 inches, the third figure ·005, being the 200th part of an inch. The end of the gauge tube was muffled or protected by a flannel cap to prevent induction. In cases of very small differences of pressure, colzalene (specific gravity, ·725) was used in the gauge, and the readings ($1\frac{1}{4}$ to 1) reduced to water column. The use of liquids of a light specific gravity was an advantage, as the small drops left on the glass quickly evaporated, and left a straighter and clearer line of surface than in cases where water was used. As an adjunct to this instrument,

500 yards of small hose pipe were kindly placed at the writer's disposal by Messrs. Angus and Co.; this tube was hung from the signal wire along the air-course, each end being suspended in the centre of the airway. (3) A Casella air-meter, the working friction of which was ascertained before making the experiments. The indicated readings of this instrument were corrected by adding 12 revolutions to velocities under, and 20 revolutions to velocities above, 1,000 feet per minute.

The absolute barometric pressure (apart from the ordinary variations, in which case the aneroid barometer readings were corrected), as well as the temperature, 60 degs. Fah., was disregarded, as they were about the same in each experiment. The loss or gain of pressure due to the different velocities at the points of observation were not taken into account, as these results made practically very little difference in the calculations. In the case of the downcast shafts the loss of pressure due to the initial velocity has been deducted.

The air measurements were made by dividing the airway into squares by strings, and holding the anemometer in the centre of each for 30 seconds; the average velocity being calculated from these readings. The readings were repeated at two or three points along the air-course, to obviate any error arising from leakage. A considerable interval of time was allowed between each experiment in each section, to allow a thorough establishment of change of velocity. It will be observed that two distinct methods of observing the difference of pressure under nearly similar conditions in most of the sections are given, which practically confirm the results arrived at. Each section was carefully levelled, and the difference of level between the two points of observation used as a correction for the barometer readings. The sectional area and perimeter were measured every few feet, and the averages are recorded. The terms regular and irregular section are deduced from the maximum and minimum areas shown in the sections. (Plates XI. to XXIII).

The airways experimented on had the variable conditions usually present in mines. In the shaft experiments the cages were at the top and bottom, or out of the shaft, so as to avoid the increased resistance from that source. The experiments were confined to the depth above the first split to avoid any alterations of velocity.

It has not been thought necessary to record each experiment in detail, as the necessary information is embodied in the summarised table.

*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*

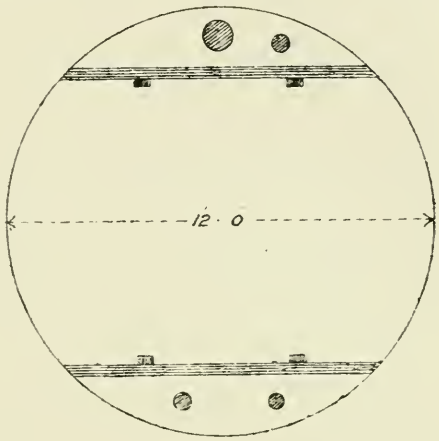
# HORIZONTAL SECTION OF SHAFTS.

SCALE. *4 Feet to ¾ of an Inch.*

## SECTIONAL AREAS.

| | | | |
|---|---|---|---|
| *Gross sectional area of shaft* | *161 Ft.* | *Gross sectional area of shaft* | *113 Ft.* |
| *Area of obstructions* | *12 "* | *Area of obstructions* | *7 "* |
| *Available sectional area* | *149 "* | *Available sectional area* | *106 "* |

## SECTION, No. 1.

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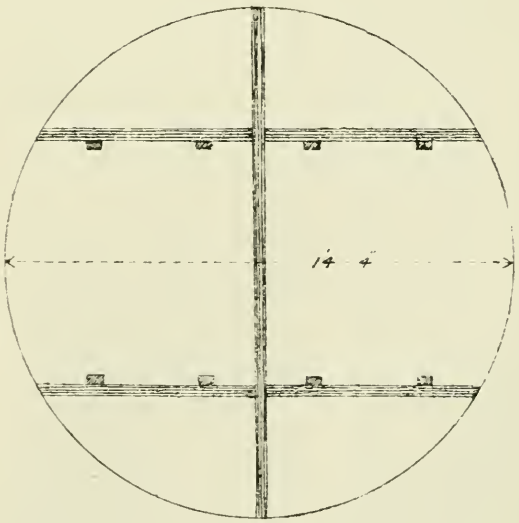


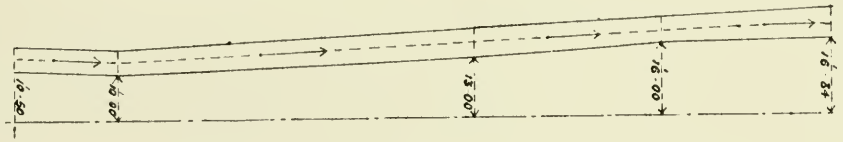



Hammer & Photolithographic Co.

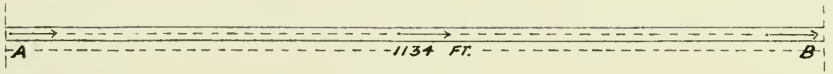
*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*



## SECTION A.B.




ELEVATION _ *20 Feet to one ½ inch*

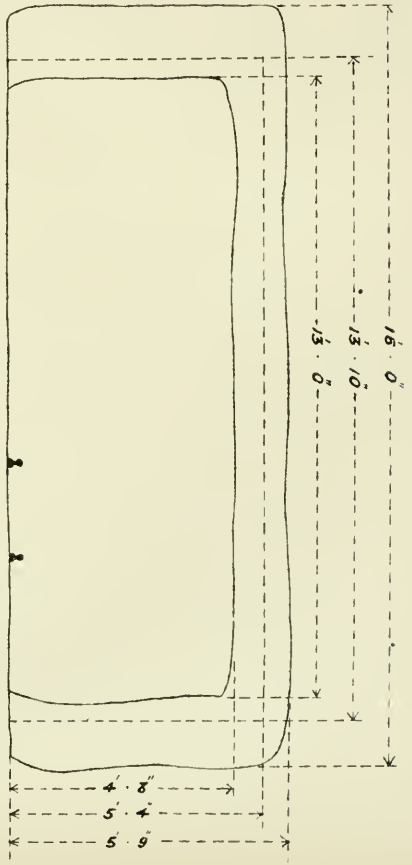



PLAN _ *2 Chains to one ½ Inch*

SECTIONAL AREAS.

MIN: ..... 60·66 FT.
MAX: ..... 86·25 FT.
GEN: AV: 73·66 FT.

SECTION.
*4 Feet to one Inch*



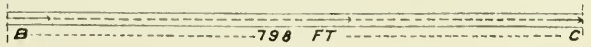



Lambert & Co LP Newcastle

*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*



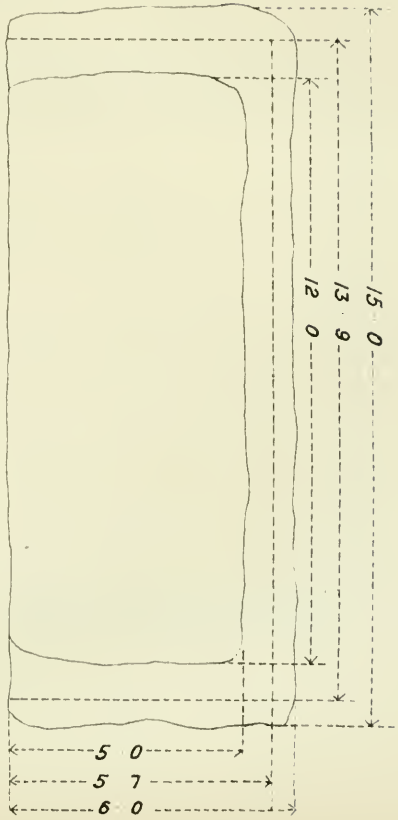
## SECTION B.C.




PLAN
*2 Chains to ½ an Inch*

ELEVATION
*20 feet to ½ an Inch*

— SECTIONAL AREA —
MIN.. 60 FT
MAX.. 90 FT
GEN AV.. 76·75 FT

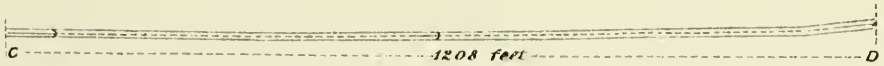



SECTION
*4 feet to one Inch*

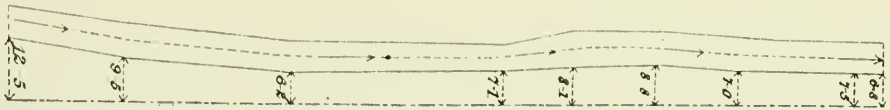
*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*



## SECTION C.D.



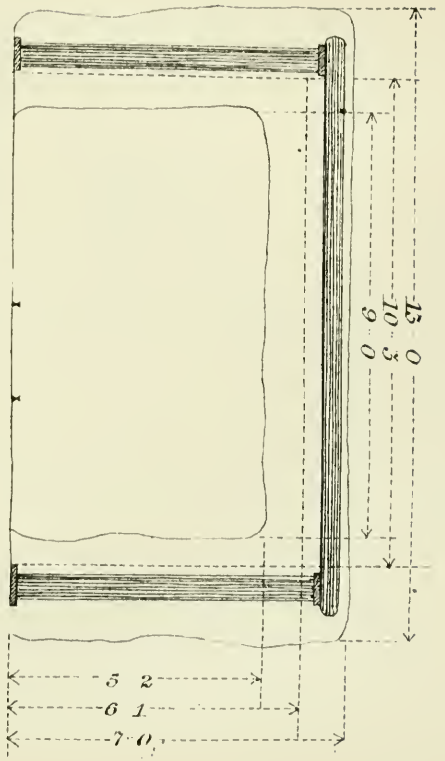

PLAN
*2 Chains to ½ an Inch*




ELEVATION
*20 feet to ½ an Inch*

— SECTIONAL AREAS —
MIN – 46·5 FT
MAX – 91·0 FT
CEN AV – 62·35 FT

SECTION *4 feet to one Inch*



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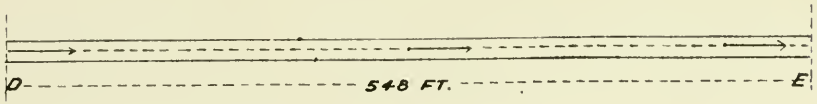
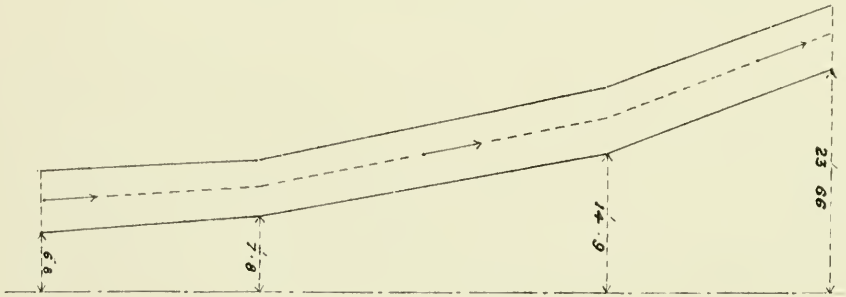
*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*






PLAN_ *2 Chains to one Inch*



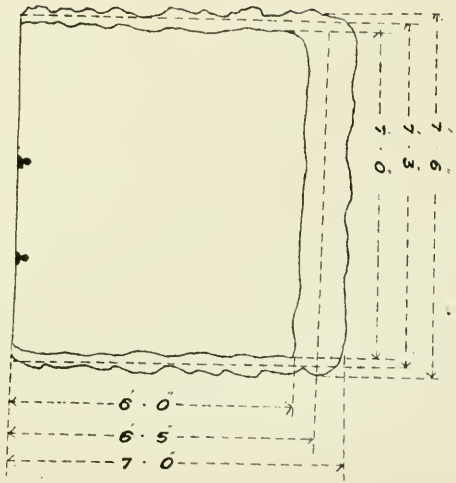

ELEVATION_ *20 Feet to one Inch*

SECTIONAL AREAS

MIN. ..... 42 FT.
MAX. ..... 52·5 FT.
GEN: AV: 46·5 FT.

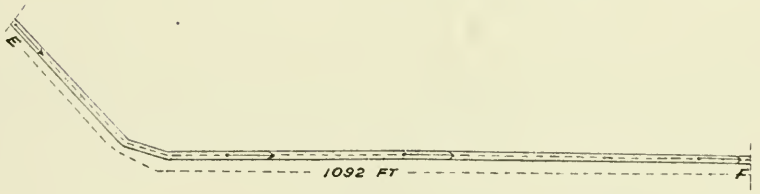
SECTION D.E.

SECTION _ *4 Feet to one Inch*



*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*

## SECTION E.F.



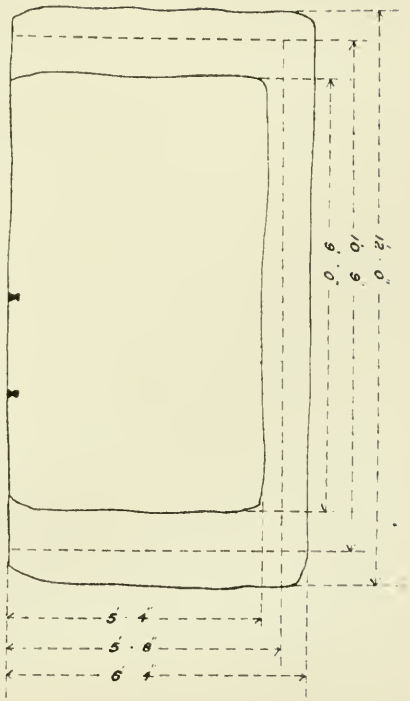

PLAN_ *2 Chains to one ½ Inch*

ELEVATION *20 Feet to one ½ Inch*

SECTIONAL AREAS

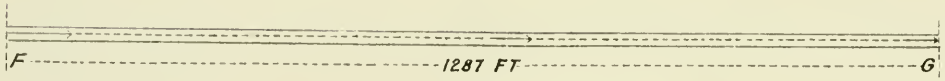
MIN: 48 FT.
MAX: 76 FT.
GEN: AV: 61 FT.

SECTION
*4 Feet to one Inch*

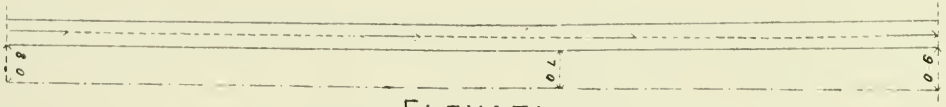


*To illustrate Mr. T. L. Elwen's "Account of Experiment on the Resistance to Air Currents in Mines."*

## SECTION F.G.



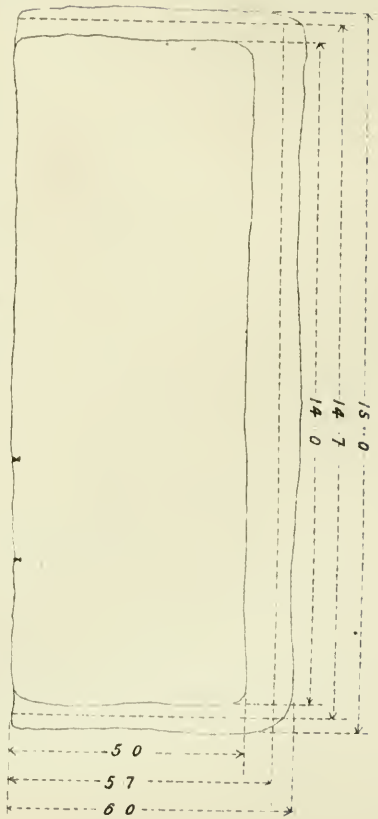

PLAN
*2 Chains to ½ an Inch*




ELEVATION
*20 feet to ½ an Inch*

SECTIONAL AREAS
MIN - 70 FT
MAX - 90 FT
CEN - AV 81 42 FT

SECTION *4 feet to one Inch*



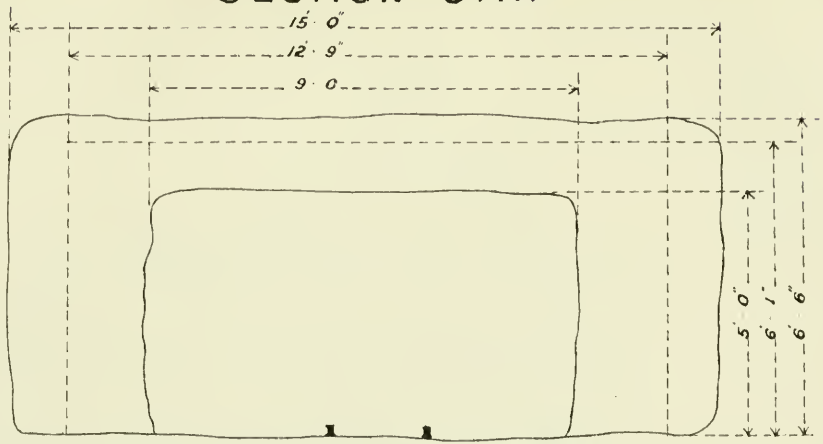



Lambert & Co. Lith. Newcastle

*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*

Vol. XXXVIII. Pl. XVIII

## SECTION G.H.




SECTION — *4 Feet to one Inch.*

**SECTIONAL AREAS**

| | |
|---|---|
| MIN: | 45 FT. |
| MAX: | 97·5 FT. |
| GEN: AV: | 77·5 FT. |

PLAN — *2 Chains to one ½ Inch*

ELEVATION — *20 Feet to one ½ Inch.*

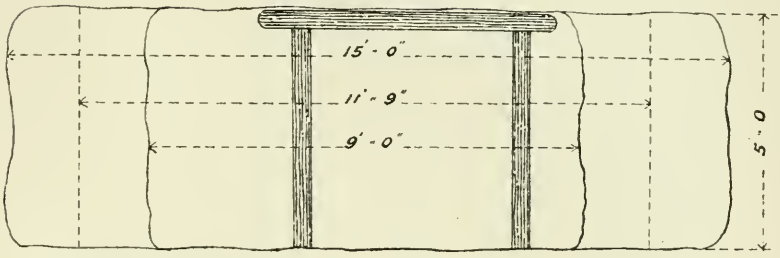


Lambert & Co. Lt. Newcastle

*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*



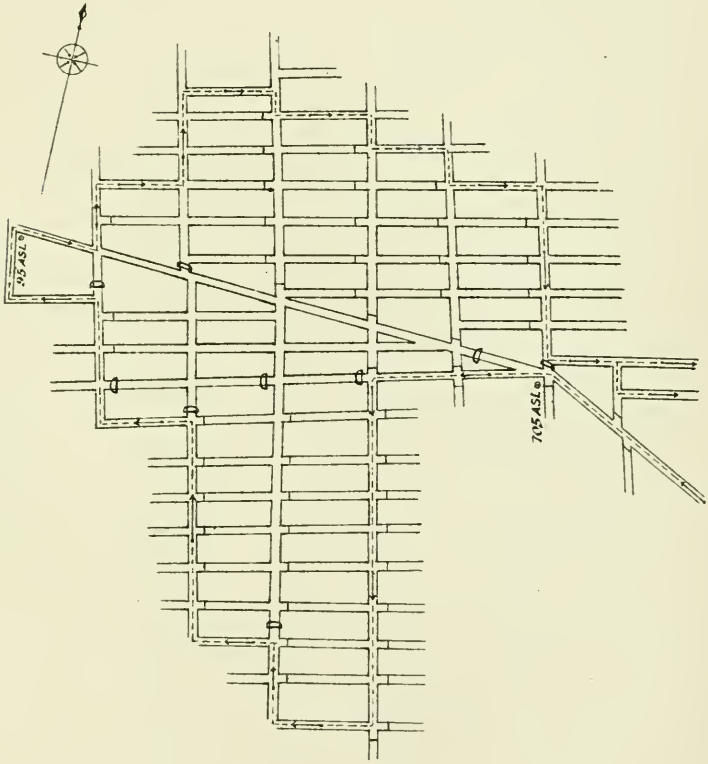
## SECTION, H. I.




SECTIONAL AREAS.

MIN:.....45, FT.
MAX:.....75 FT.
GEN: AV: 58·88, FT.

SECTION.
*4 Feet to one Inch.*




## PLAN.
*2 Chains to one ½ Inch*

REFERENCES.

⟶ INDICATE THE DIRECTION OF THE AIRCURRENT.
DOORS. STOPPING.
AIRCROSSING.

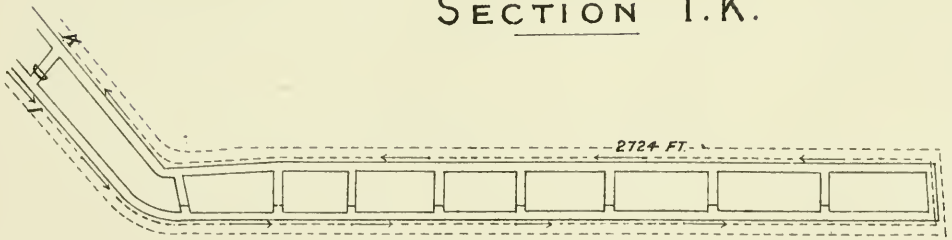


Lambert & Co Lt Newcastle

*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*



## SECTION I.K.




PLAN *2 Chains to one ½ Inch*

ELEVATION *20 Feet to one ½ Inch*

REFERENCES

INDICATES - INTAKE

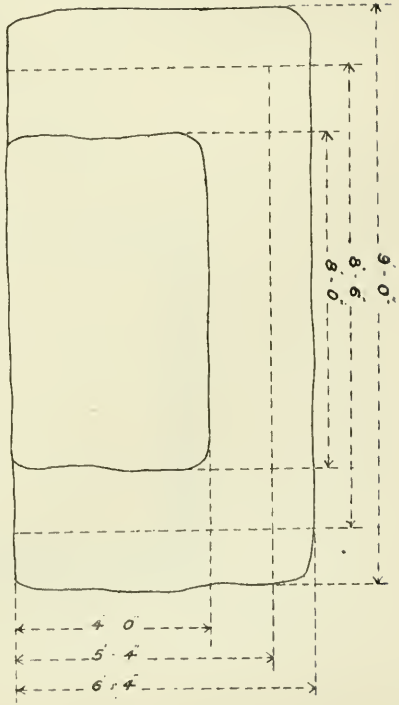
INDICATES - RETURN

SECTIONAL AREAS

MIN:.....28 FT.

MAX:.....76 FT.

GEN: AV: 50·56 FT.




SECTION. *4 Feet to one Inch*



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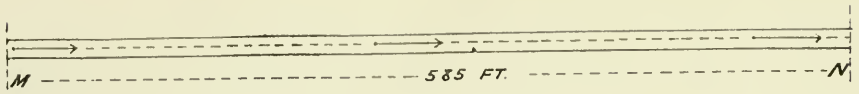
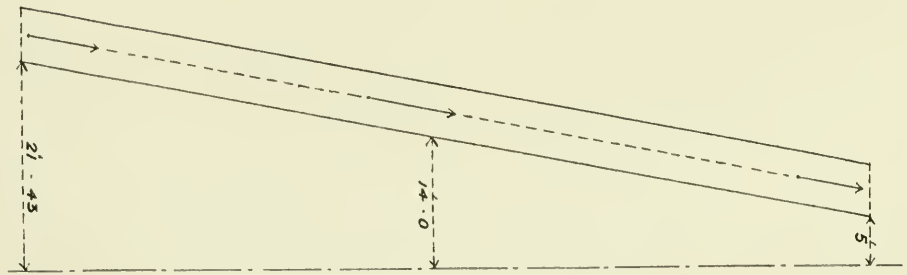
*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*





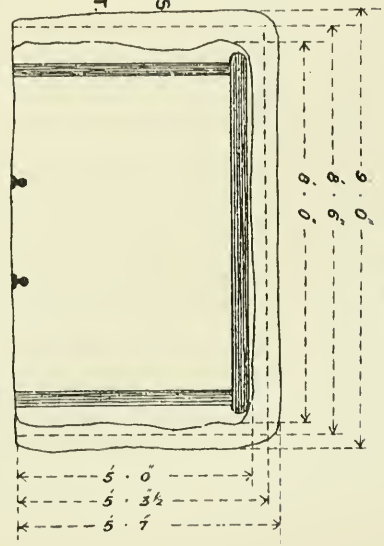

PLAN *2 Chains to one Inch*




ELEVATION_*20 Feet to one Inch*

SECTION M.N.

SECTIONAL AREAS
MIN: 40 FT.
MAX: 50·25 FT.
GEN: AV: 45 FT.



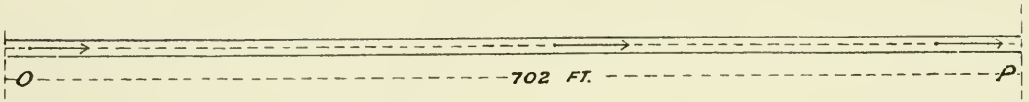

SECTION_*4 Ft to one Inch*



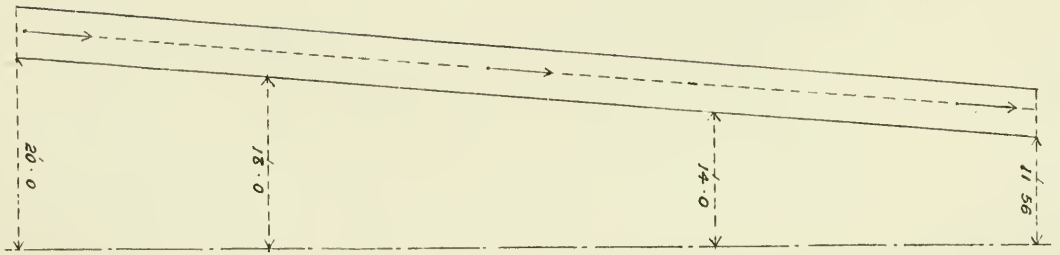
Lambert & Co. Ld. Newcastle

*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*






PLAN *2 Chains to one Inch*

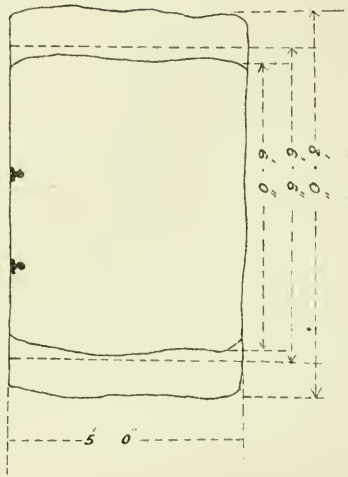



ELEVATION *20 Feet to one Inch*

SECTIONAL AREAS

MIN. ..... 30 FT.
MAX. ..... 40 FT.
GEN: AV. ... 32·5 FT.

SECTION *4 Ft. to one Inch*



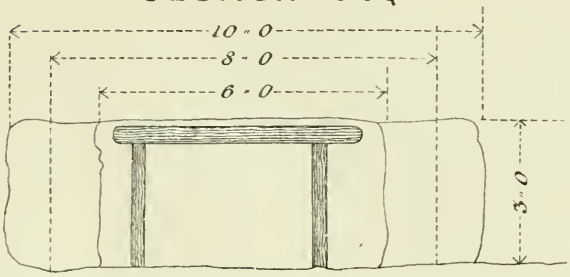

SECTION O.P.



Lambert & Co. Lt. Newcastle.

*To illustrate Mr. T. L. Elwen's "Account of Experiments on the Resistance to Air Currents in Mines."*

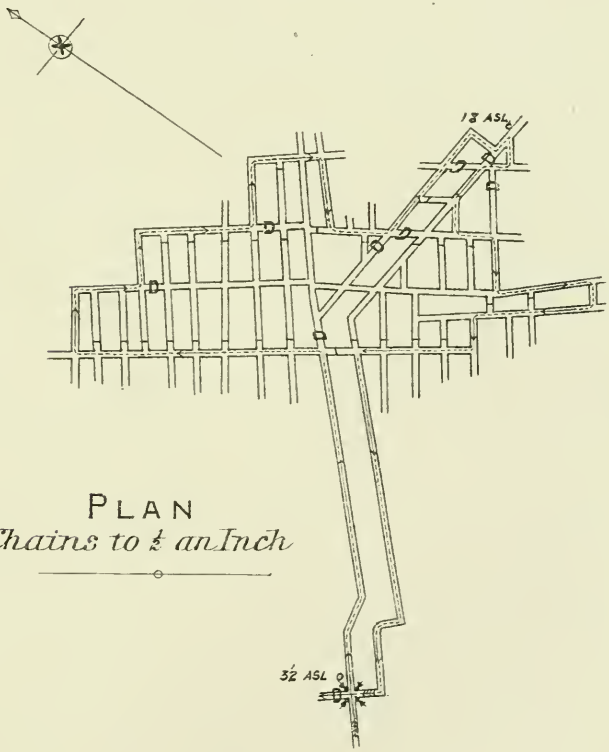
## SECTION P.Q




SECTIONAL AREAS

MINIMUM - 18 FEET
MAXIMUM - 30 FEET
GENERAL AVERAGE - 24 FEET

SECTION
*4 feet to one Inch.*




PLAN
*2 Chains to ½ an Inch*

REFERENCES

*indicates the direction of the aircurrent*
*Doors* *Stopping*
*Aircrossing*



Lambert & Co.LP Newcastle

Under the head of barometer readings, column 11 shows the indicated difference in feet, between the two points of observation; thus, in the first experiment in section A B, the reading at A was 665, and at B 775, or a difference in ascent of 10 feet, but as B was 6·34 feet above A this amount is deducted from the readings, because, in addition to the resistance, the barometer indicated the difference of level between the two ends of the roadway. For the same reason where the end of the section is below the commencement, the difference of level is added. A further illustration is shown in section No. 1 for downcast shaft, the depth of which was 1,030 feet, the indicated reading of the instrument was 979, therefore, 1,030 — 979 = 51 feet of air column absorbed by the resistance as shown in column 12. Then, as a column of air one foot high and one foot square exercises a pressure of 0·076 lbs., the difference of pressure is found by multiplying the feet of air column by this factor, and the results recorded in column 13 are obtained. In the case of downcast shafts, there is another loss of pressure apart from the current resistance, viz., that due to creating the initial velocity at the top of the shaft. The recognised rule for this is $h = V^2 \div 64{\cdot}4$, where h = head of air column necessary to create the velocity in feet per second; $V^2$ = square of the velocity in feet per second. However, in the two examples given (sections Nos. 1 and 2), the head was found to be more than that ascertained by using the above formula. To prove this, experiments were made at the tops of several downcast shafts, and it was found that the actual velocity resulting from the deflection of the air particles into the centre of the shaft was higher than the apparent velocity (quantity of air divided by the sectional area at the top of the shaft), and amounted to an increase, represented by a co-efficient of ·80 of the sectional area. This is an average; as a slight difference existed due to the varying conditions of entry, by the existence of gates and contiguity of surrounding buildings, as well as the prevalence of winds. For example, in section No. 1, the total difference of pressure is 51 ÷ 13·13 = 3·884 lbs. per square foot, but the current resistance in the shaft was shown to be 2·437 lbs.; therefore, 3·884 — 2·437 = 1·447 lbs. due to initial velocity. The quantity of air descending the shaft was 143,653 cubic feet per minute, the sectional area at the top of the shaft 85·35 feet, and the apparent velocity of the air 143,653 ÷ (85·35 × 60) = 28·052 feet per second. Then, according to the understood rule, $28{\cdot}052^2 \div 64{\cdot}4 = 12{\cdot}219$ feet of air column, or 12·219 ÷ 13·13

| Section. | Description of Airway. | Length in Feet. | Average Perimeter in Feet. | Total amount of rubbing surface. | Average sectional area. | Difference of level between the two points of observation. | No. of Exp. | Quantity of air in cubic feet per minute. |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | | | Sq. ft. | Sq. ft. | Feet. | | |
| A B | Straight airway in coal seam. Main haulage road. Very regular in section. No timber ... ... .. ... | 1,134 | 38·33 | 43,470 | 73·66 | 6·34 | 1<br>2<br>3<br>4 | 34,048<br>50,979<br>33,338<br>48,748 |
| B C | Ditto. | 798 | 38·66 | 30,856 | 76·75 | 0·90 | 1<br>2<br>3<br>4 | 41,250<br>69,271<br>40,716<br>62,246 |
| C D | Straight airway in coal seam. Main haulage road. Irregular section. Very much timber ... ... ... ... | 1,208 | 32·66 | 39,453 | 62·35 | 5·70 | 1<br>2<br>3<br>4<br>5<br>6<br>7 | 37,518<br>47,385<br>61,633<br>26,895<br>34,673<br>42,174<br>25,096 |
| D E | Straight airway in post stone (drift). Main haulage road. Regular section. Very jagged sides. No timber ... | 548 | 27·33 | 14,977 | 46·50 | 16·86 | 1<br>2<br>3<br>4<br>5<br>6 | 37,518<br>50,304<br>19,440<br>32,617<br>49,770<br>25,181 |
| E F | Straight airway in coal seam. Main haulage road. A little irregular in section. Some timber... ... ... | 1,092 | 32·825 | 35,845 | 61·00 | 2·80 | 1<br>2<br>3 | 39,978<br>34,680<br>22,446 |
| F G | Straight airway in coal seam. Main haulage road. Very regular section. No timber ... ... ... ... | 1,287 | 40·33 | 51,905 | 81·42 | 1·00 | 1<br>2<br>3<br>4 | 10,764<br>20,848<br>40,716<br>64,740 |
| G H | Straight intake airway in coal seam. Irregular section. No timber ... ... | 2,230 | 37·66 | 83,982 | 77·50 | 15·81 | 1 | 18,480 |
| H I | Bord and pillar face of workings. Irregular section. No. of bends, 21. Timber plentiful. Air conveyed through innermost holing round face ... ... | 3,279 | 33·55 | 110,010 | 58·88 | — | 1 | 7,320 |
| I K | Intake and return airway in coal seam. Very irregular section. No timber ... | 2,724 | 29·49 | 80,330 | 50·56 | — | 1<br>2<br>3 | 9,240<br>19,908<br>35,196 |
| M N | Straight intake airway in coal seam. Regular section. Very much timber | 585 | 27·58 | 16,136 | 45·00 | 16·43 | 1<br>2 | 12,993<br>11,076 |
| O P | Straight intake airway in coal seam. Regular section. No timber ... ... | 702 | 23·00 | 16,146 | 32·50 | 8·44 | 1<br>2 | 6,037<br>5,300 |
| P Q | Bord and pillar face of workings. Irregular section. No. of bends, 30. Timber plentiful. Air conveyed through innermost holing round face ... ... | 3,178 | 21·70 | 68,962 | 24·00 | — | 1<br>2<br>3<br>4 | 1,000<br>2,140<br>3,320<br>4,000 |
| 1 | Downcast shaft (timbered) ... ... ... | 1,030 | 37·7 | 38,793 | 106·00 | 1,030 | 1 | 143,653 |
| 2 | Ditto. | 1,309 | 44·97 | 58,868 | 149·00 | 1,309 | 1 | 300,000 |

REFERENCES.—P = Difference of pressure in lbs. per square foot. A = Sectional area of airway. Q = Quantity of air
† Corrected for

| Average velocity in feet per minute. | Barometer Readings. | | | Water Gauge. | | Total difference of pressure (P × A). | Total units of work. (Q × P). | Co-efficient of resistance in lbs. on the whole section of the airway per square foot of rubbing surface. Calculated for a velocity of 1,000 feet per minute. $\left(\frac{P \times A}{S \times V^2}\right)$ | Velocity of air in feet per minute at points of observation of pressure. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Difference in Feet. | Corrected for difference of level. | Difference of pressure in lbs. per square foot. | Water Gauge in inches. | Difference of pressure in lbs. per square foot. | | | Lbs. per square foot. | At beginning of section. | At end of section. |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | | | | | | Lbs. | | | | |
| 462 | 10 | 3·66 | 0·278 | — | — | 20·477 | 9,465 | | 549 | 454 |
| 692 | 15 | 8·66 | 0·659 | — | — | 48·542 | 33,595 | | 822 | 680 |
| 453 | — | — | — | 0·060 | 0·312 | 22·982 | 10,401 | | 538 | 440 |
| 662 | — | — | — | 0·125 | 0·650 | 47·879 | 31,686 | ·002513 | 786 | 650 |
| 538 | 6 | 5·10 | 0·385 | — | — | 29·548 | 15,881 | — | 550 | 516 |
| 903 | 14 | 13·10 | 0·998 | — | — | 76·597 | 69,132 | — | 924 | 866 |
| 530 | — | — | — | 0·075 | 0·390 | 29·932 | 15,889 | — | 543 | 509 |
| 811 | — | — | — | 0·150 | 0·780 | 59·865 | 48,552 | ·002950 | 830 | 778 |
| 602 | 11 | 16·70 | 1·272 | — | — | 79·309 | 47,723 | — | 417 | 441 |
| 760 | 21 | 26·70 | 2·033 | — | — | 126·757 | 96,333 | — | 526 | 557 |
| 988 | 40 | 45·70 | 3·480 | — | — | 216·978 | 214,483 | — | 685 | 725 |
| 431 | 3 | 8·70 | 0·663 | — | — | 41·338 | 17,831 | — | 299 | 316 |
| 556 | — | — | — | 0·200 | 1·040 | 64·844 | 36,060 | — | 385 | 408 |
| 676 | — | — | — | 0·300 | 1·560 | 97·266 | 65,791 | ·005595 | 468 | 496 |
| 402 | — | — | — | 0·110 | 0·572 | 35·664 | 14,355 | — | 279 | 295 |
| 807 | 28 | 1·14 | 0·848 | — | — | 39·432 | 31,815 | — | 834 | 800 |
| 1,082 | 36 | 19·14 | 1·458 | — | — | 11·113 | 4,646 | — | 1118 | 1,070 |
| 418 | 20 | 3·14 | 0·239 | — | — | 67·797 | 73,343 | — | 432 | 414 |
| 701 | — | — | — | 0·130 | 0·676 | 31·434 | 22,049 | — | 725 | 694 |
| 1,070 | — | — | — | 0·300 | 1·560 | 72·540 | 77,641 | ·004230 | 1105 | 1,059 |
| 542 | — | — | — | 0·075 | 0·390 | 18·135 | 9,821 | — | 559 | 536 |
| 655 | 15 | 12·20 | 0·930 | — | — | 56·730 | 37,179 | — | 615 | 740 |
| 568 | — | — | — | 0·135 | 0·702 | 42·822 | 24,345 | ·003703 | 533 | 642 |
| 368 | — | — | — | 0·070 | 0·364 | 22·204 | 8,170 | — | 345 | 416 |
| 131 | — | — | — | 0·006 | 0·031 | 2·524 | 332 | — | 138 | 134 |
| 256 | — | — | — | 0·025 | 0·130 | 10·585 | 2,710 | — | 267 | 260 |
| 500 | — | — | — | 0·100 | 0·520 | 42·338 | 21,172 | ·003263 | 522 | 509 |
| 795 | — | — | — | 0·260 | 1·352 | 110·080 | 87,528 | — | 830 | 809 |
| 238 | 13 | 2·81 | 0·214 | — | — | 16·585 | 3,955 | ·003486 | 217 | 246 |
| 124 | — | — | — | 0·079 | 0·411 | 24·188 | 3,007 | ·014239 | 98 | 98 |
| 230 | — | — | — | 0·108 | 0·561 | 28·364 | 5,183 | — | 171 | 205 |
| 496 | — | — | — | 0·468 | 2·431 | 122·911 | 48,396 | ·005510 | 368 | 442 |
| 877 | — | — | — | 1·295 | 6·734 | 340·471 | 237,009 | — | 652 | 780 |
| 289 | 15 | 1·43 | 0·109 | — | — | 4·905 | 1,416 | — | 277 | 289 |
| 246 | — | — | — | 0·020 | 0·104 | 4·680 | 1,152 | ·004792 | 236 | 246 |
| 186 | 8 | 0·44 | 0·033 | — | — | 1·075 | 199 | — | 168 | 155 |
| 163 | — | — | — | 0·006 | 0·031 | 1·007 | 164 | ·002349 | 147 | 136 |
| 42 | — | — | — | 0·020 | 0·104 | 2·496 | 104 | — | 33 | 40 |
| 89 | — | — | — | 0·070 | 0·364 | 8·736 | 779 | — | 75 | 85 |
| 138 | — | — | — | 0·130 | 0·676 | 16·224 | 2,244 | — | 111 | 133 |
| 166 | — | — | — | 0·200 | 1·040 | 24·960 | 4,160 | ·013132 | 133 | 160 |
| 1,355 | 979 | 51 | +2·437 | — | — | 258·322 | 350,082 | ·003626 | — | 1,355 |
| 2,013 | 1,203 | 106 | +6·000 | — | — | 894·000 | 1,800,000 | ·003746 | — | 2,113 |

in cubic feet per minute. S = Area of rubbing surface. $V^2$ = Square of the velocity in thousands of feet per minute.
initial velocity.

= 0·93 lbs., or a difference of 1·447 — ·930 = ·517 lbs., due to the *vena contracta*. The co-efficient is found as follows :—

$$\frac{28{\cdot}052}{\sqrt{1{\cdot}447 \times 13{\cdot}13 \times 8}} = {\cdot}81.$$ The water gauge readings in inches are multiplied by 5·2, and yield the difference of pressure in pounds per square foot recorded in column 15. The total difference of pressure in column 16 is found by multiplying the pressure in lbs. per square foot by the average sectional area of the airway. The total units of work expended in each section is given in column 17, and is found by multiplying the quantity of air by the difference of pressure in lbs. per square foot. The co-efficient of resistance given in column 18 is expressed in terms of lbs. per square foot, for each square foot of rubbing surface, and for a standard velocity of 1,000 feet per minute, and is equal to the total pressure divided by the superficial area of the rubbing surface in feet multiplied by the square of the velocity in thousands of feet per minute. The co-efficient for each section is calculated, as a rule, from the experiment in such section which has the highest velocity with water-gauge readings, or as near as possible the standard velocity which has been adopted. For example, in the fourth experiment in section A B the total difference of pressure is 47·879 lbs., the average velocity 662 feet per minute, and the area of rubbing surface is 43,470 square feet. Then,

$$\frac{47{\cdot}879}{43{,}470 \times {\cdot}662^2} = {\cdot}002513$$ lbs., the required co-efficient.

The most important thing to observe in these experiments is the great difference in the values of the co-efficient of resistance shown in column 18. To account for this difference it is necessary to explain the cause of the resistance to moving air in airways. The particles of air directly in contact with the sides, top, and bottom of the airway are constantly being deflected at varying angles from the general direction of the air-course, and thus retarded in their motion; this is most apparent with a very uneven rubbing surface, or where the projections are greatest, and its influence felt to the centre of the current, as seen by dividing the section of an airway into squares, and observing the velocity in each. In this way some parts of the rubbing surface are not subject to the action of the ordinary current, but to eddies, as may be seen by observing the deposited dust at projections, &c.

The velocity of the current changes continuously from the surface towards the centre of the airway, and is very small indeed close to the rubbing surface.

Apart from the additional rubbing surface offered to the air in an airway by the presence of timber which, of course, increases the resistance, the sectional area of the airway at these points at the same time is reduced and the velocity increased, causing an additional two-fold cause of resistance. In airways, the timber being at intervals, the current is alternately increased and decreased in velocity. The brattice, &c., in a shaft is a constant reduction of area, and the amount of this obstruction is properly deducted, and the nett area only used for calculations. In the former case the obstruction by timber is not deducted.

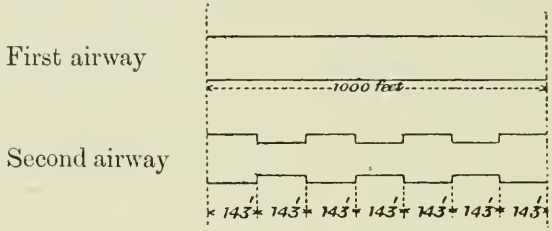
The repeated enlargements and contractions of an airway is another source of resistance to the air. The beneficial effect of an enlargement may be more than compensated by the additional head required to get up the velocity again at a contraction, as well as that lost by eddies at every sudden enlargement. The greater the variation in this respect the greater, proportionately, will be the loss of pressure from this source. This principle may be in active operation in an airway with falls of stone, &c., and may be compared to as many regulators in it. Every reduction of area from the general size of the airway is a *vena contracta*, the *rationale* of which (as deduced from experiments on doors, regulators, &c.) is that the resistance is expressed by $h = V^2 \div 64{\cdot}4$, the velocity in this case being further increased by the reduction of area due to the deflection of the air particles into the centre. The co-efficient of contraction depends upon the conditions of entry. Thus, for the entrance of air from a still atmosphere into a downcast shaft, the co-efficient equals ·80, and for a reduction of area in airways depends upon whether part or the whole of the perimeter is reduced in area, or, in other words, upon the amount of perimeter deflecting the air particles, as well as upon the velocity of the current immediately before entering the contraction. Thus, as the air, before entering the contraction, approaches the contracted part, the co-efficient increases from ·75 to 1·00. For example in two airways, both of the same average sectional area throughout. Quantity of air, 30,000 cubic feet per minute.

First airway :—Section. 10 feet × 5 feet = 50 square feet area, and velocity, 600 cubic feet per minute.

Second airway :—

Large parts :—Section, 10 feet × 5·75 feet = 57·5 square feet area, and velocity, 522 feet per minute.

Small parts :—Section, 8 feet × 5 feet = 40 square feet area, and velocity, 750 feet per minute.




Therefore, head for initial velocity in first airway $10^2 \div 64{\cdot}4 = 1{\cdot}55$ feet.

For second airway, head for initial velocity $8{\cdot}7^2 \div 64{\cdot}4 = 1{\cdot}19$ feet, and for each of the succeeding contractions—$750 \div (\cdot 9 \times 60) =$ 13·89 feet per second (corrected for *vena contracta*, ·9 being taken as the co-efficient), and $13{\cdot}89^2 \div 64{\cdot}4 =$ 3 feet × 3 feet contraction = 9 feet.

Summarising, we have :—$1{\cdot}19 + 9 = 10{\cdot}19 - 1{\cdot}55 = 8{\cdot}64$ feet, and $8{\cdot}64 \div 13{\cdot}13 = 0{\cdot}658$ lbs. per square foot loss of pressure in the second airway in excess of the first airway, due to the contractions alone. The amount of current resistance on the sides, &c., is not here taken into account, the results from this source, however, do not vary much in the two examples given.

Thus, for first airway, taking ·002 lbs. as the co-efficient, 30,000 square feet of rubbing surface, ·6 the velocity of air in thousands of feet per minute, and sectional area being 50 square feet :

$$\frac{\cdot 002 \times 30{,}000 \times \cdot 6^2}{50} = 0{\cdot}432 \text{ lbs. per square foot.}$$

For second airway :—

Large parts :—Rubbing surface 4,505 square feet, ·522 being velocity of air in thousands of feet per minute, and sectional area being 57·5 square feet :

$$\frac{\cdot 002 \times 4{,}505 \times \cdot 522^2}{57{\cdot}5} = 0{\cdot}0427 \text{ lbs. per square foot,}$$

and $0{\cdot}0427 \times 4 = 0{\cdot}1708$ lbs. per square foot.

Small parts:—Rubbing surface 3,718 square feet, ·750 being velocity of air in thousands of feet per minute, and sectional area being 40 square feet:

$$\frac{\cdot002 \times 3{,}718 \times \cdot75^2}{40} = 0{\cdot}10457 \times 3 = 0{\cdot}31371 \text{ lbs. per}$$

square foot. Total, 0·17080 + 0·31371 = 0·48451 lbs. per square foot for second airway, showing a difference of ·48451 − ·43200 = ·05251 lbs. per square foot in favour of first or large airway.

Therefore, taking the total resistance in each airway:—

| | Initial velocity. | | Current resistance. | | |
|---|---|---|---|---|---|
| First airway ... | ·120 | + | ·43200 | = | ·55200 |
| Second airway ... | ·776 | + | ·48451 | = | 1·26051 |

and the difference ... ... ... = 0·70851 lbs. per square foot. The total resistance is thus more than doubled in the second airway.

A change in the direction of the airway is an effective way of increasing the resistance, the volume of air being greatly deflected at such points.

The resistance arising from the retardation of air particles on a plane surface is comparatively small; the alternate increase and decrease in the velocity of the current, the degree of smoothness of the sides, &c., and change of direction of the air current, being the most important factors in the loss of pressure. To what extent these agencies severally operate now remains to be shown.

By referring to the summary, it is seen that airways which are straight, very even in section, without timber, and driven in the coal seam, give the least resistance, as in sections A B, B C, F G, and O P, the average of which, at a standard velocity of 1,000 feet per minute, yields a co-efficient equal to ·002769 lbs. per square foot of rubbing surface. The sections E F and G H were more irregular in section, and, consequently, the co-efficient in their case averages ·003594 lbs. Section D E is an example of an airway (stone drift) having very rough sides, &c., where the co-efficient was ·00423 lbs. The effect of timber in an airway is shown in section MN, with a co-efficient of ·004792 lbs. Downcast shafts, with smooth sides, but having timber, are shown in sections 1 and 2, and average ·003686 lbs. In exceptional cases, where the shaft is free from obstructions, the co-efficient will be much less. Section I K is an airway of considerable irregularity in section, and shows a co-efficient of ·00551 lbs. Irregularity of

section, with the presence of much timber (section C D) gives a co-efficient of ·005595 lbs. The whole of these factors of resistance are present in sections H I and P Q, which represent a bord and pillar face of workings, and give a co-efficient of ·013685 lbs. In this case the amount of resistance is doubled by bratticing the workings in advance. The co-efficient in all these cases represents the total pressure which must be distributed over the transverse section of the airway for every square foot of rubbing surface, in order to maintain a velocity of 1,000 feet per minute in the airway. It will be seen that this is a constant quantity for the same kind of surface, being independent of the dimensions of the airway. For a given area of rubbing surface, the pressure per square foot required to drive the air, that is, the pressure measured by the water-gauge varies inversely as the area of the section. The following is a summary of these results :—

| | Co-efficient in lbs. per square foot of rubbing surface, velocity 1,000 feet per minute. |
|---|---|
| Straight airways, very even in section, without timber, driven in the coal seam ... ... ... ... ... ... | ·002769 |
| Straight airways, irregular section, without timber, driven in the coal seam ... ... ... ... ... ... ... | ·003594 |
| Straight airways, regular section, without timber, very jagged sides ... ... ... ... ... ... ... ... | ·004230 |
| Straight airways, regular section, timber plentiful, driven in the coal seam ... .. ... ... ... ... ... | ·004792 |
| Shafts timbered (buntons or brattice) ... ... ... ... | ·003686 |
| Straight airways, very irregular section, without timber, driven in the coal seam ... ... ... ... ... | ·005510 |
| Straight airways, driven in the coal seam, irregular section, plenty of timber ... ... ... ... ... ... | ·005595 |
| Airways round bord and pillar face of workings ... ... | ·013685 |

For these different conditions, taking the first description as the basis, there is an increase of ·002023 lbs., or 73 per cent., due to the presence of timber; for irregularity of section, an increase of from ·000825 lbs. to ·002741 lbs., or from 29 per cent. to 99 per cent.; for timber and irregularity of section, ·002826 lbs., or 102 per cent.; for a stone drift with very rough sides, ·001461 lbs., or 53 per cent.; for timber, irregularity of section, and bends, ·010916 lbs., or 394 per cent.

It is proper to observe that the amount of resistance expressed in the co-efficient for airways that are timbered, and have an irregularity of section, is reckoned as if the resistance due to these extraneous causes was expended in the current resistance on the sides

On account of the great difference in the value of the co-efficients, it is impossible to adopt one suitable for the whole of a mine. Greater accuracy will be obtained by treating shafts intakes, workings, and returns separately. Having in view the general condition of the above parts of a mine, the following co-efficients might be adopted for use in calculation :—

| | Co-efficient in lbs. per square foot of rubbing surface, velocity 1,000 feet per minute. |
|---|---|
| Shafts ... ... ... ... ... ... ... ... ... | ·0037 |
| Intakes ... .. ... ... ... ... ... ... ... | ·0042 |
| Workings ... ... ... ... ... ... ... ... | ·0137 |
| Returns ... ... ... ... ... ... ... ... ... | ·0056 |

It is hardly necessary to point out the practical deductions to be drawn from these experiments; it may, however, be noted that, next to having the airways large in section, the most important thing is to keep them as straight and regular in size as possible.

Little attention is generally given to the arrangement of the junction of return air currents. In the case of two currents of equal velocities approaching each other from opposite directions, the effect of the one on the other is equal; but if the velocities are different, the weaker current suffers severely. Where the junction is at right angles, the straight-on current exercises a most detrimental effect on the other, especially if the velocities are very different, and this is most apparent in upcast shafts. Of course, the amount of resistance in each case is considerable, but may be reduced by erecting a guiding brattice to bring the currents gradually together.

Another point to be noticed is the relation existing between the velocity, the pressure, and the power. The well-known rule that the pressure required to overcome the resistance varies as the square, and the power as the cube of the velocity, is practically confirmed in these experiments, by the relationship existing between the various velocities, pressures, and powers in each section, and was maintained under the varying conditions of the airways. In the course of making some of these experiments it was observed that, after altering the velocity in a short airway, the correct difference of pressure was almost immediately established, whilst in a long airway, after increasing the velocity, the indicated difference of pressure was as much as 20 per cent. above the correct difference, obtained after allowing a considerable interval of time to elapse so

that the inertia of the air might be overcome. In one instance (section I K) of a long airway, after increasing the velocity four-fold, the pressure did not come up to that equal to the square of the velocity by about one-fifth, owing to the momentum acquired by the air. In airways of very great length, and with a corresponding increase of velocity, this difference will be even greater, and becomes an important factor in the calculations.

Appended are plans, sections, and elevations of the galleries experimented on (Plates XI. to XXIII.) It may be observed that the ventilation arrangements shown on these plans are not those in the ordinary course of working, but were specially arranged for the experiments. In conclusion, I wish to express my indebtedness to the several colliery viewers and others who have assisted me in making these experiments, and especially to Mr. M. Walton Brown and Professor Garnett for their valuable assistance on the technical points connected with this paper.

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*Corrigenda.*

Plate XIX.
Section H I. On Plan :—
For 705 A S L ⊕, read 70·5 A S L ⊕
Plate XX.
Section I K. Figures on top of section.
For 9 feet 0 inch, read 12 feet 0 inch.
For 8 feet 6 inches, read 9 feet 6 inches.
For 8 feet 0 inch, read 7 feet 0 inch,
Reverse the direction of arrows in the elevation.

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The President left the meeting to catch a train, and the chair was taken by Mr. Willis.

The Chairman said this seemed to be a very valuable paper, and one which would require more study than could be given to it in a meeting like this. He should be glad to hear any observations as to the mode of the experiments, or their result. The paper would be open for discussion at a future meeting, after they had had an opportunity of studying it.

Professor W. Garnett said he thought this was a type of paper that would be very valuable to this Institution; it was a paper containing a number of experimental results which he thought would

prove exceedingly useful. He was puzzled for some time to make out how the co-efficient per square foot of resistance was expressed; and at last he concluded that the pressure in pounds meant the total pressure which would have to be exerted over the whole area of the drift-way, and would be divided by the number of square feet in the area of the drift-way, in order to obtain the pressure per lb. per square foot of the rubbing surface. More information was needed as to the remarks upon the effect of narrowings in the seam. If that narrowing was introduced by means of a trumpet-mouth constructed in the drift-way, and if when the drift enlarged again a trumpet-mouth was introduced, they would get rid altogether of the great loss of power which appeared in the account of the amount of work that had to be done to give the increased energy to the air. Whether it would be worth while to introduce such complications for the sake of the saving of power in maintaining ventilation was another question. He explained an experiment which was made on the Merrimac in the discharge of water from locks, to show the effect of the trumpet-mouth on moving water. With respect to the use of the barometer in the different sections, it appeared to him that the pressure could not be properly recorded; and he proceeded to explain this by referring to the difference in the velocity between the points where the velocity was 1,000 feet and 200 feet.

Mr. ELWEN said that, placing a barometer in a particular place at the commencement of a section where the velocity was 100 feet per minute, and at the end of the section where it was 1,000 feet, the velocity of the air had no effect upon the readings of the barometer.

Professor GARNETT said the barometer would read perhaps correctly, but the difference in the two readings between the higher and lower velocities would have to be considered in recording the result.

The CHAIRMAN: I understand Mr. Elwen to say that the barometer does not show any difference between the higher and lower velocities.

Mr. ELWEN: It shows, of course, the difference from the current resistance.

Professor GARNETT: You put it down as resistance.

Mr. ELWEN: There is very little difference of velocity at the beginning and end of any of the sections.

Professor GARNETT: If the 1,000 feet came first, and the 100 feet afterwards, so that there was a falling off of velocity, the barometer

might show exactly the same pressure at either of the two points, but it would not be correct to say there was no difference of pressure between the two points.

Mr. WALTON BROWN asked Mr. Elwen to add to the table the velocity at the different points, and members could then form their own opinion upon the matter. The co-efficients given by Mr. Elwen were similar to those derived from the results* of experiments in Belgium, as follows :—

| | For a velocity of 1,000 feet per minute and a rubbing surface of one square foot. | |
|---|---|---|
| | Pressure in pounds per square foot of area of section. | Height of water-gauge in inches. |
| Averages of all the galleries of a coal mine ... ... ... | ·00936 | ·00180 |
| At the face of the workings ... | ·01419 | ·00273 |
| Galleries and pits of uniform section, and without obstructions ... ... .. ... | ·00208 | ·00040 |

The CHAIRMAN said the discussion seemed to indicate that members wanted a little time to look into the matter.

The CHAIRMAN said they could not separate without thanking Mr. Elwen for his paper. Mr. Elwen was one of the younger members and they must express a hope that this would be an encouragement to many young members to favour the Institute with papers. They had had a very interesting paper by Mr. Embleton, one of the oldest members. He thought some of the younger members might more frequently favour them with papers. He knew there was a great amount of modesty among the young men in the coal trade—at least there was when he was a young man; but still they could favour the Institute with little papers on interesting matters, remembering that the big papers were simply a number of little ones. He moved a vote of thanks to Mr. Elwen.

Mr. WALTON BROWN seconded the vote of thanks, which, he said, would be a very inadequate return to Mr. Elwen for the time he had spent on the experiments.

This was agreed to, and the meeting concluded.

* See Potts' Mining Register for 1889, pages 24—30.

# PROCEEDINGS.

ANNUAL GENERAL MEETING, SATURDAY, AUGUST 3RD, 1889, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

MR. JOHN MARLEY, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected:—

MEMBERS—

Lieut.-Colonel JASPER GUSTAVUS SILVESTER DAVIES, R.E., Marton, Middlesbrough.

Mr. JAMES KENNETH GUTHRIE, Eltringham Colliery, Prudhoe, R.S.O.

Mr. JEREMIAH HEAD, Coatham, Redcar.

Mr. WILLIAM WALKER, Jun., H.M. Inspector of Mines, Durham.

ASSOCIATE MEMBERS—

Mr. T. C. HUTCHINSON, Hilda House, Middlesbrough.

Mr. ARTHUR PRANGLEY WILSON, 12, Barkston Mansions, South Kensington, London.

ASSOCIATE—

Mr. JOHN GEORGE GUY, Seaham Colliery, Sunderland.

The following gentlemen were nominated for election:—

MEMBERS—

Mr. JOHN HODGSON, Edomsley Colliery.

Mr. EDWARD HOPKINS, Weardale Place, St. John's Chapel.

Mr. THOMAS ROBERT MADDISON, Dirtcar House, Wakefield.

Mr. W. TOPLEY, F.R.S., F.G.S., 28, Jermyn Street, London, S.W.

ASSOCIATE MEMBERS—

Mr. FREDERICK GOSMAN, Neville Hall, Newcastle-upon-Tyne.

Mr. R. NORMAN REDMAYNE, 26, Grey Street, Newcastle-upon-Tyne.

STUDENTS—

Mr. WALTER BELL, 23, Windsor Crescent, Newcastle-upon-Tyne.

Mr. PERCY OCTAVIUS WEIGHTMAN, Barrow Colliery, Barnsley.

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The PRESIDENT appointed Messrs. M. Walton Brown, W. C. Blackett, and C. C. Leach scrutineers for the election of officers for the ensuing year.

The SECRETARY read the annual reports of the Council and of the Finance Committee.

The PRESIDENT said there were several points in the report to which he would like to draw attention. The first of these was the settlement, he trusted, of the membership question. The classes of honorary members and of students remained unaltered. The professional members had hitherto made a payment of three guineas per annum, and the Council found that this arrangement had not been acceptable, and the increase of numbers under that head had not met their expectations. This had been remedied by the new Bye-Laws, and they had now four classes of subscribers: the member who was the former professional or ordinary member; the associate, or non-professional member; a special class for under-viewers, under-managers of mines, and gentlemen occupying similar positions in engineering, who could now have all the advantages of the Institute, and privileges of other classes, except voting in connexion with the management, for a payment of one guinea per annum; and students. The professional members' payment has been reduced from three to two guineas, the same as the non-professional class. Another feature of the report was the addition of forty-two members during the year, prior to the reduction of the subscription, and it was hoped that with the alterations alluded to, the number of members would increase, more especially owing to the advantages which would be derived in future from the Federated Institution of Mining Engineers. He would impress upon the members the necessity of increasing the number of associates, for they would be a strength to the Institute.

He desired to draw attention to the meeting of the British Association, which would meet next month in the City of Newcastle-upon-Tyne, and to the arrangement by which members of this Institute were allowed to read their papers both before this Institute and the British Association.

He would like to emphasize the work of the various committees appointed by the Council. The Fan Committee, appointed jointly by three Institutions, and from whose report much benefit was anticipated. Another, which hoped to be shortly in possession of funds to enable it to commence operations, was the Flameless Explosives Committee.

The Durham College of Science, as was stated in the report, had now, with the advice and revision of the Council, agreed upon a course of Mining and Engineering instruction for two years. This, he thought, opened a field of wide importance in connexion with

the College, and also with the Institute. The particulars had been printed, and would be issued with the Transactions.

The Federation of Mining Institutes, which the late Secretary (Mr. T. W. Bunning) took such a great interest in promoting, and which was the subject of the last paper he read before the Institute, had assumed a definite shape, and he (the President) thought they could report something as having been already done. An arrangement had been made between four Institutes, to commence the experiment and ascertain whether it would succeed, and they believed it would succeed. The first meeting of the Council of the Federated Institution of Mining Engineers for the election of officers would be held during the week of the meeting of the British Association. The members of this Institute had elected fourteen members on the Council, all of whom were experienced men in connection with the management of Mining Institutes; six of them had been Presidents, five Vice-Presidents, and three were members of the Council. It was expected that the first meeting of the Federated Institution would take place in January next, at Sheffield.

In moving the adoption of the report, he expressed the hope that the incoming year would end with improved circumstances and increased number of members.

Mr. GEO. BAKER FORSTER said he had much pleasure in seconding the adoption of the report; he hoped they were entering on a year which would be more satisfactory than the past one had been. They were now on rather a broader basis as regards constitution, and he hoped it might lead to an increased membership, and to a larger attendance at the General Meetings. They might perhaps drop a hint to many of the members as to the meetings on Saturday afternoons, and tell them they ought to come and help. No doubt the Council would, now that things were fairly under weigh, provide the meetings with very many interesting things which would deserve attention.

The reports were unanimously adopted.

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Mr. WM. ARMSTRONG, Jun., read a paper on "The Economical Working of Steam Boilers at Collieries." by Messrs. W. Armstrong, Jun., and W. J. Bird.*

* This paper is printed in the "Transactions of the Federated Institution of Mining Engineers," Vol. I, page 309-325.

## DISCUSSION ON "THE ECONOMICAL WORKING OF STEAM BOILERS AT COLLIERIES."

Mr. W. COCHRANE, referring to the concluding phrase that "all disturbing factors have been taken into consideration, and their effect discounted so as to arrive at a true comparison," said he would like to ask Mr. Armstrong whether what he called "ash" was similar in each case of analysis. Where so great a difference as 17 and 31 per cent. of ash resulted from using the same coals, in one case with the mechanical firing, and in the other with the Juckes bars, that ash would possibly have been found to be unconsumed coal, and the Juckes, which he thought as perfect as the other, must have been over-run, and would probably be found to have discharged coal at the other end. If that was so, and the ash not exactly of the same kind as that discharged by the other apparatus, the percentage of ash would be defective in that particular, and would be misleading as to the value of many of the results which Mr. Armstrong had calculated. Without referring to the paper, he (Mr. Cochrane) thought that an apology was made, in a measure, for bad results obtained, in some cases, by connecting them with the increase of ash, an item, which it seemed to him, had the coals and ash been properly tested in the respective trials, would probably have resulted in a different manner.

Mr. W. ARMSTRONG, Jun., agreed that most of the ash given by the Juckes bars was unconsumed coal, but the Juckes bars did not involve the use of the same amount of coal. He thought those in question were too wide apart and favoured too rapid combustion to give a fair test; at a great many collieries where they were properly constructed and not too wide, they gave good results. The results were not given with a view of deprecating the Juckes bars.

Mr. A. L. STEAVENSON said it was scarcely a subject which could be dealt with until the members had the paper before them. He made experiments twenty-three years ago, and Mr. Cochrane was engaged on the same matter at that time, with the general result that the use of mechanical firing, whether the Juckes or the Vickers bars, was a decided advantage. The boilers were saved, as the writers of the paper stated, from the injurious action of heating and cooling, but the great saving of all was in labour. In the present case the difference of cost of labour was not shown, but he hoped before the next meeting this would be given. The enormous amount of work accomplished was striking; 57 tons of water were evaporated in twenty-four hours with a

38 feet boiler. He generally considered 25 tons for a 45 or 50-feet boiler was as much as could be done, but here, with regular heating, a 50-feet boiler gives 50 tons in twenty-four hours, and, in one case, by hand-firing he saw they had actually exceeded that, having got 57 tons. This was an extraordinary result to get from a 41-feet egg-ended boiler, and was the largest duty he had ever met with; he could only account for it by the very large quantity of coal used during the time; the weight of coal was stated as 9 tons, and this, for an egg-ended boiler in twenty-four hours, was a very large quantity. For ordinary purposes, where a colliery worked ten or eleven hours a day, he generally assumed that it required 3 tons of coal in twenty-four hours as compared with 9 in this case.

Mr. ARMSTRONG explained to Mr. Steavenson that the tests were forty-eight hour tests.

Mr. STEAVENSON said that accounted for the difference, and agreed more with his statement, as it brought the amount to 4½ tons in the twenty-four hours. He suggested that the figures should be put into a more convenient shape. Naturally they would expect the heat in the chimney to be very great when driving the fire so hard. It amounted in one case to 940 degrees Fahr., which was a good deal higher than he considered desirable if they wished to do economical work. However, they must have time to study the paper more carefully; he was much obliged to Messrs. W. Armstrong, Jun., and W. J. Bird for bringing the subject forward. Mechanical firing was an advantage, and since the first tests were made the arrangements had been very much improved, and he could very well understand that better results would be given now than many years ago.

Mr. J. A. G. ROSS said that there could be no dispute about the advantage of mechanical firing over hand-firing. He had not yet seen particulars of the comparisons of hand-firing with the Henderson mechanical appliance, but as far as the heating of boilers was concerned, there could be no question that a regular supply of fuel and of atmospheric air was the best method of heating a boiler. When the doors were open there was a plethora in the supply of atmospheric air, causing the bars to be cooled with it; and when the doors were closed they had too little air. In one case it cooled the boiler, and in the other there was incomplete combustion, producing carbon monoxide instead of carbon dioxide. As a matter of principle, mechanical firing must essentially be superior to hand-firing, but

he failed to see why any particular system of mechanical firing was better than another. It was a matter of experience entirely; he found that the best firing was secured by the Juckes system, which had been referred to. The patent was now expired, and any one might use it. As an engineer, he had been able to burn absolute rubbish as fuel with it, which could not have been used with any other furnace. The quantity of fuel could be regulated as well as the speed of travel, and at the end of the bar it could be exceedingly thin, or they could have nothing at all upon it. In regard to one point referred to by the writers of the paper, it seemed to him that, if it was carried out, it would revolutionize the whole system of engine-construction, viz.: that if they extended the boiler to a considerable length, they got very little increase of efficiency; that did not seem to coincide with the progress of engineering during recent years, otherwise, why have tubes in locomotive boilers? If Mr. Armstrong and Mr. Bird were right in stating that the extension of surface did not result in increased efficiency, then the whole system of locomotive and marine engineering was wrong! There was, of course a limit.

Mr. W. Armstrong, Jun., said with reference to burning refuse with the Juckes bars, he did not for a moment dispute the fact, but with the Henderson bars they now used, they burned common coke breeze, with the result that they evaporated 300 gallons of water per hour. As to the difference in length, 10 feet of material of relatively low conductivity like iron, would not represent anything like the increased surface of a locomotive or marine boiler with a conductivity like brass or copper, which probably affected the result.

Mr. H. Lawrence said he had used a Juckes furnace for a great number of years. He put some in for Mr. W. Cochrane about twenty-eight years ago, and, without comparing what had been brought before the meeting, he would state that the statistics given as the results of the experiments with the Juckes furnace did not come within 100 per cent. of results he had obtained from similar experiments. He would like particularly to ask, so that Mr. Armstrong might be prepared at some future meeting, the size of the fire-bars used in the experiments with hand-firing? They all knew that with the barbarous practice of having $2\frac{1}{2}$-inch bars with $\frac{3}{4}$-inch spaces between them, the coal was not burned, but wasted. It was, therefore, important to know whether the hand-firing was conducted in a proper manner, such as that adopted at the present time; that

is to say, very thin bars and a good proportion of combustion chambers—distributed throughout the whole of the area of the fire-grate.

Mr. ARMSTRONG agreed with Mr. Lawrence, and suggested that it would be advantageous if tests were made on the two furnaces at the Grange, and he would be very glad if Mr. Lawrence could arrange for this to be done.

Mr. LAWRENCE thought he had the results of some experiments which, he believed, were made at Page Bank some years ago on a Juckes furnace, which gave 10 pounds of water evaporated per pound of fuel.

Mr. A. L. STEAVENSON said his sympathies were certainly with Juckes bars, having had them so many years; they were very useful when kept in order, but they were very troublesome if allowed to get out of order.

Professor GARNETT said there was one point which struck him as exceedingly interesting: the very small difference made by $\frac{1}{16}$th of an inch of scale on the interior of the boiler. The view he took of it was not quite consistent with that which Mr. Armstrong expressed with reference to the greater length of the egg-ended boiler. It seemed to him to show, what they knew from other sources to be the case, that the conductivity of the material of which the boiler was made, was of very little importance indeed, in fact the $\frac{1}{16}$th of an inch of stone (as it might be called) deposited on the interior of the boiler would add greater resistance to the passage of heat than the whole thickness of the boiler-plate. As a matter of fact the difference in temperature of the two sides of the boiler-plate was only six or seven degrees, with one thousand degrees between the furnace gases and the inside. The great difficulty was the layer of comparatively cold air, which clung to the surface of iron on one side, and the very thin layer of steam on the other. The material used was of little importance. This was so well understood by marine engineers, on the Tyne at all events, that they put in the same amount of heating surface to a marine boiler, whether using iron, bronze, brass, or Muntz metal tubes. Another point which might be elucidated later on, was the condition of the furnace-gases in entering the chimney. The whole question of the efficiency of a boiler appeared to him to be capable of settlement without any experiment whatever on the water evaporated or the coal burnt. The efficiency of a boiler could be determined by the examination of the temperature and nature of the gases in the

uptake. If, for instance, it was shown that there were no unconsumed combustible gases present, they knew that the whole combustible material in the coal, except what might fall into the ashpit, was consumed, and the whole corresponding heat generated. If, further, the analysis showed that there was no great excess of oxygen, they knew no more air was being employed than was absolutely necessary for combustion of the gases; and, lastly, if the temperature in the uptake was not more than 350 degrees Fahrenheit or some such reasonable temperature, sufficient to produce chimney draught, they could not expect to get the gases cooled more than they had been. If the coal was consumed, heat must be produced; if not up the chimney, it must go into the water, because the loss by radiation from the surface was comparatively small. In acting on the water it must produce steam; therefore, if they knew the amount and composition of the coal used, the proportion of ash, and the temperature and nature of the gases in the uptake, they could determine accurately, or at least within 1 per cent., the evaporative power of the boiler, and avoid the necessity of weighing feed water and the like.

Mr. W. Armstrong said it did not occur to them to state the comparisons in this way, and they were obliged to Professor Garnett for the idea. He quite agreed with the Professor with regard to the temperature of the waste gases, and on referring to the pyrometer observations, it would be seen that Lancashire boilers gave lower temperatures than egg-ended boilers with patent fires (25 degrees' difference of temperature). He thought that in a very short time experiments would be made on the nature of the gases.

Mr. Lawrence thought it would be well if they could have the sizes of the flues of the plain cylindrical boiler. It was stated that in a 41-feet boiler the temperature of the gases escaping up the chimney was 780 degrees. He found that with a boiler 45 or 46 feet long, and 5 feet diameter, properly constructed with bridges, he had reduced it to less than 500 degrees.

Mr. G. B. Forster said he had pleasure in proposing a vote of thanks to the writers of the paper. The subject was one which attracted great attention in this district at present, and he might state that the Northumberland Coal Owners' Association had advertized for particulars of various contrivances and appliances for producing complete combustion of the fuel. There was no doubt that the general feeling was in favour of some appliances of the kinds described being adopted, especially in the case of north-country

coal. Experiments had been made at his collieries with the Bennis apparatus, and he would be pleased to supply particulars when the discussion came on again. He thought it a very great advantage that such subjects should be considered by this Institute, and they were greatly indebted to the writers of the paper for opening a discussion which he hoped would become exhaustive, and include all the various kinds of apparatus in use.

Mr. T. H. M. STRATTON seconded the vote of thanks, which was carried unanimously.

Mr. ARMSTRONG, in reply, said he hoped they would be favoured with the experience of members, and if any gentleman would like to inquire into the method of carrying out the experiments recorded, he would be happy to see them at Wingate, and to show them the whole of the appliances.

# BAROMETER AND THERMOMETER READINGS FOR THE YEAR 1888.

By M. WALTON BROWN.

The barometer, thermometer, etc., readings have been supplied by permission of the authorities of the Glasgow and Kew Observatories, and give some idea of the variations of temperature and of atmospheric pressure in the intervening districts in which the mining operations of this country are chiefly carried on.

The barometer at Kew is 34 feet, and at Glasgow is 180 feet, above sea-level. The barometer readings at Glasgow have been reduced to 32 feet above sea-level, by the addition of ·150 inch to each reading, and the barometer readings at both Observatories are reduced to 32 degs. Fahr.

The fatal explosions in collieries are obtained from the annual reports of H.M. Inspectors of Mines, and are printed upon the diagrams recording the meteorological observations.

## BAROMETER READINGS, &c.

### JANUARY, 1888.

| KEW. | | | | | | | | GLASGOW. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer. | | | | Temperature. | | | | Barometer. | | | | Temperature. | | |
| Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | Direction of wind at noon | Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | Direction of wind at noon |
| 1 | 29·795 | 29·651 | 29·487 | 29·383 | 37·9 | 24·9 | SE | 1 | 29·617 | 29·513 | 29·357 | 29·253 | 36·3 | 30·8 | SE |
| 2 | 29·322 | 29·328 | 29·309 | 29·416 | 45·0 | 37·2 | S | 2 | 29·092 | 29·048 | 29·151 | 29·292 | 35·8 | 29·9 | S |
| 3 | 29·717 | 29·934 | 30·010 | 30·035 | 43·2 | 32·2 | NW | 3 | 29·438 | 29·619 | 29·638 | 29·599 | 42·5 | 35·0 | SSE |
| 4 | 29·979 | 29·935 | 29·798 | 29·718 | 42·9 | 39·6 | S | 4 | 29·363 | 29·423 | 29·375 | 29·381 | 47·5 | 42·1 | ESE |
| 5 | 29·643 | 29·678 | 29·806 | 29·960 | 48·4 | 38·9 | SW | 5 | 29·365 | 29·377 | 29·473 | 29·701 | 45·3 | 38·6 | NW |
| 6 | 30·073 | 30·163 | 30·116 | 30·108 | 45·4 | 31·5 | SW | 6 | 29·799 | 29·795 | 29·745 | 29·829 | 46·9 | 38·4 | SE |
| 7 | 30·147 | 30·285 | 30·354 | 30·423 | 49·3 | 42·3 | WNW | 7 | 29·906 | 30·025 | 30·052 | 30·058 | 48·4 | 43·7 | WSW |
| 8 | 30·444 | 30·499 | 30·524 | 30·588 | 51·1 | 43·0 | W | 8 | 30·102 | 30·218 | 30·332 | 30·388 | 49·9 | 46·1 | SSW |
| 9 | 30·626 | 30·675 | 30·674 | 30·690 | 48·3 | 37·4 | WNW | 9 | 30·437 | 30·493 | 30·509 | 30·557 | 50·6 | 42·3 | SW |
| 10 | 30·683 | 30·700 | 30·674 | 30·675 | 43·4 | 32·7 | W | 10 | 30·539 | 30·533 | 30·531 | 30·551 | 47·1 | 41·9 | SW |
| 11 | 30·646 | 30·656 | 30·601 | 30·615 | 36·5 | 31·4 | W | 11 | 30·537 | 30·559 | 30·531 | 30·519 | 44·5 | 39·1 | WSW |
| 12 | 30·599 | 30·617 | 30·612 | 30·634 | 37·9 | 34·4 | W | 12 | 30·510 | 30·516 | 30·520 | 30·558 | 39 8 | 34·4 | WSW |
| 13 | 30·632 | 30·643 | 30·628 | 30·624 | 37·5 | 35·4 | N | 13 | 30·545 | 30·613 | 30·621 | 30·639 | 40·9 | 33·8 | NNE |
| 14 | 30·578 | 30·535 | 30·504 | 30·520 | 35·3 | 29·8 | SE | 14 | 30·626 | 30·616 | 30·588 | 30·614 | 41·7 | 38·1 | NE |
| 15 | 30·476 | 30·471 | 30·446 | 30·427 | 36·1 | 32·3 | ENE | 15 | 30·607 | 30·611 | 30·591 | 30·599 | 39·4 | 37·5 | ENE |
| 16 | 30·408 | 30·419 | 30·423 | 30·461 | 34·2 | 32·3 | E | 16 | 30·559 | 30·577 | 30·541 | 30·555 | 38·6 | 35·4 | NE |
| 17 | 30·480 | 30·514 | 30·507 | 30·517 | 34·9 | 29·3 | E | 17 | 30·555 | 30·567 | 30·571 | 30·575 | 37·1 | 31·9 | NE |
| 18 | 30·523 | 30·553 | 30·596 | 30·640 | P34·3 | 27·9 | E | 18 | 30·569 | 30·597 | 30·595 | 30·603 | 36·9 | 31·2 | ENE |
| 19 | 30·643 | 30·630 | 30·574 | 30·533 | 35·3 | 32·1 | ESE | 19 | 30·591 | 30·531 | 30·449 | 30·405 | 33·5 | 27·0 | NNW |
| 20 | 30·490 | 30·490 | 30·451 | 30·411 | 39·1 | 30·0 | SW | 20 | 30·357 | 30·311 | 30·259 | 30·153 | 39·7 | 32·8 | ESE |
| 21 | 30·250 | 30·067 | 29·913 | 29·877 | 49·8 | 39·1 | SW | 21 | 29·905 | 29·755 | 29·649 | 29·663 | 47·0 | 39·2 | SW |
| 22 | 29·821 | 29·883 | 29·935 | 30·048 | 48·0 | 43·9 | W | 22 | 29·709 | 29·793 | 29·843 | 29·965 | 47·3 | 42·6 | SW |
| 23 | 30·173 | 30·343 | 30·398 | 30·436 | 50·2 | 38·7 | NW | 23 | 30·052 | 30·118 | 30·096 | 30·058 | 48·9 | 44·3 | SW |
| 24 | 30·425 | 30·443 | 30·423 | 30·423 | 45·0 | 36·9 | W | 24 | 30·014 | 30·084 | 30·086 | 30·008 | 48·6 | 45·8 | SSW |
| 25 | 30·365 | 30·330 | 30·193 | 30·055 | 45·2 | 39·9 | SW | 25 | 29·923 | 29·849 | 29·703 | 29·425 | 47·8 | 39·4 | SSW |
| 26 | 29·857 | 29·864 | 30·103 | 30·235 | 46·8 | 38·0 | NW | 26 | 29·482 | 29·903 | 30·083 | 30·193 | 42·7 | 35·7 | NW |
| 27 | 30·249 | 30·223 | 30·003 | 29·921 | 43·0 | 31·3 | WNW | 27 | 30·187 | 30·057 | 30·021 | 30·085 | 40·0 | 29·8 | WSW |
| 28 | 29·903 | 29·965 | 29·972 | 29·966 | 38 1 | 29·4 | NNW | 28 | 30·086 | 30·104 | 30·062 | 30·044 | 36·5 | 27·4 | SW |
| 29 | 29·917 | 29·945 | 30·027 | 30·084 | 36·8 | 26·1 | NE | 29 | 30·057 | 30·097 | 30·091 | 30·061 | 38·3 | 24·5 | SSE |
| 30 | 30·087 | 30·081 | 29·990 | 29·874 | 35·8 | 24·2 | NW | 30 | 29·981 | 29·899 | 29·767 | 29·453 | 40·0 | 31·9 | WSW |
| 31 | 29·649 | 29·380 | 29·211 | 29·300 | 40·0 | 32·1 | WSW | 31 | 29·173 | 29·231 | 29·471 | 29·731 | 39·4 | 33·3 | NNE |

### FEBRUARY, 1888.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29·569 | 29·800 | 29·945 | 30·074 | 34·0 | 25·0 | NE | 1 | 29·907 | 30·013 | 30·039 | 30·037 | 36·7 | 30·2 | ENE |
| 2 | 30·117 | 30·150 | 30·098 | 30·074 | 34·6 | 21·6 | WSW | 2 | 30·079 | 29·885 | 29·679 | 29·693 | 44·8 | 30·8 | SSE |
| 3 | 29·995 | 30·018 | 30·025 | 30·087 | 44·3 | 31·9 | WSW | 3 | 29·804 | 29·838 | 29·814 | 29·854 | 46·1 | 39·0 | SW |
| 4 | 30·116 | 30·193 | 30·244 | 30·323 | 50·9 | 40·8 | WNW | 4 | 29·931 | 30·063 | 30·105 | 30·107 | 46·9 | 43·0 | S |
| 5 | 30·302 | 30·267 | 30·207 | 30·190 | 49·9 | 40·9 | WNW | 5 | 30·033 | 30·045 | 30·057 | 30·109 | 49·0 | 45·1 | SSW |
| 6 | 30·186 | 30·242 | 30·253 | 30·296 | 51·3 | 40·0 | N | 6 | 30·136 | 30·180 | 30·160 | 30·116 | 49·0 | 45·0 | SW |
| 7 | 30·265 | 30·199 | 30·146 | 30·132 | 49·0 | 40·9 | WNW | 7 | 30·066 | 30·072 | 30·028 | 29·946 | 46·6 | 40·8 | WSW |
| 8 | 30·036 | 29·971 | 29·938 | 29·962 | 49·2 | 41·2 | NW | 8 | 29·876 | 29·898 | 29·874 | 29·828 | 48·3 | 44·7 | WSW |
| 9 | 29·928 | 29·981 | 30·006 | 30·006 | 48·8 | 42·2 | NW | 9 | 29·873 | 29·917 | 29·855 | 29·777 | 46·0 | 36·8 | WSW |
| 10 | 29·918 | 29·840 | 29·705 | 29·691 | 47·7 | 36·2 | W | 10 | 29·632 | 29·562 | 29·550 | 29·512 | 38·8 | 31·4 | SW |
| 11 | 29·668 | 29·619 | 29·473 | 29·414 | 43·1 | 34·6 | SW | 11 | 29·441 | 29·407 | 29·343 | 29·325 | 34·7 | 27·3 | WSW |
| 12 | 29·418 | 29·490 | 29·507 | 29·570 | 38·8 | 31·0 | WNW | 12 | 29·310 | 29·354 | 29·352 | 29·384 | 37·0 | 25·9 | SW |
| 13 | 29·587 | 29·717 | 29·755 | 29·653 | 39·8 | 30·9 | W | 13 | 29·398 | 29·468 | 29·566 | 29·714 | 35·8 | 26·8 | WSW |
| 14 | 29·549 | 29·539 | 29·556 | 29·660 | 37·1 | 32·9 | S | 14 | 29·800 | 29·914 | 29·970 | 30·046 | 39·2 | 30·6 | WNW |
| 15 | 29·774 | 29·891 | 29·986 | 30·029 | 36·3 | 32·8 | N | 15 | 30·113 | 30·203 | 30·237 | 30·289 | 37·7 | 26·0 | NW |
| 16 | 30·023 | 30·096 | 30·099 | 30·103 | 35·8 | 32·4 | NNE | 16 | 30·322 | 30·348 | 30·264 | 30·170 | 33·4 | 20·3 | E |
| 17 | 30·009 | 29·967 | 29·995 | 29·965 | 35·1 | 30·4 | N | 17 | 30·004 | 30·106 | 30·154 | 30·182 | 40·9 | 29·1 | WNW |
| 18 | 29·949 | 29·886 | 29·683 | 29·553 | 39·9 | 32·1 | N | 18 | 30·055 | 29·913 | 29·829 | 29·727 | 40·7 | 31·3 | WSW |
| 19 | 29·456 | 29·443 | 29·448 | 29·441 | 35·7 | 29·8 | NE | 19 | 29·741 | 29·869 | 29·905 | 29·911 | 36·5 | 29·4 | N |
| 20 | 29·497 | 29·637 | 29·647 | 29·700 | 37·9 | 30·2 | NE | 20 | 29·885 | 29·961 | 30·033 | 30·101 | 38·7 | 33·4 | N |
| 21 | 29·730 | 29·761 | 29·748 | 29·763 | 36·1 | 32·5 | NE | 21 | 30·083 | 30·069 | 29·999 | 30·017 | 39·1 | 34·5 | WNW |
| 22 | 29·767 | 29·822 | 29·823 | 29·885 | 32·5 | 29·2 | NE | 22 | 30·025 | 30·047 | 30·039 | 30·085 | 37·3 | 33·8 | NNE |
| 23 | 29·901 | 29·965 | 29·968 | 30·009 | 30·9 | 27·3 | ENE | 23 | 30·110 | 30·178 | 30·200 | 30·222 | 36·0 | 33·3 | NNE |
| 24 | 29·989 | 29·969 | 29·919 | 29·952 | 30·0 | 22·8 | NE | 24 | 30·223 | 30·239 | 30·207 | 30·219 | 34·5 | 32·4 | NNW |
| 25 | 29·916 | 29·919 | 29·939 | 30·059 | 33·8 | 22·1 | NE | 25 | 30·226 | 30·234 | 30·204 | 30·210 | 36·0 | 32·1 | NNW |
| 26 | 30·046 | 30·071 | 30·049 | 30·090 | 34·4 | 26·4 | NE | 26 | 30·252 | 30·302 | 30·290 | 30·328 | 37·4 | 33·8 | NNE |
| 27 | 30·108 | 30·161 | 30·188 | 30·278 | 35·0 | 31·8 | NE | 27 | 30·340 | 30·410 | 30·446 | 30·510 | 38·8 | 34·9 | NNE |
| 28 | 30·315 | 30·383 | 30·361 | 30·391 | 33 6 | 29·7 | NNE | 28 | 30·517 | 30·527 | 30·511 | 30·511 | 37·9 | 34·0 | NW |
| 29 | 30·362 | 30·347 | 30·262 | 30·245 | 33·9 | 27·8 | NNE | 29 | 30·485 | 30·497 | 30·455 | 30·475 | 39·2 | 33·7 | ENE |

# BAROMETER READINGS, &c.

## MARCH, 1888.

| KEW. | | | | | | | | GLASGOW. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BAROMETER. | | | | TEMPERATURE. | | | | BAROMETER. | | | | TEMPERATURE. | | |
| Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | Direction of wind at noon | Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | Direction of wind at noon |
| 1 | 30·222 | 30·291 | 30·272 | 30·276 | 34·0 | 27·1 | ENE | 1 | 30·447 | 30·461 | 30·333 | 30·317 | 40·0 | 31·8 | NE |
| 2 | 30·223 | 30·162 | 30·009 | 29·919 | 40·3 | 25·3 | NW | 2 | 30·186 | 30·086 | 29·933 | 29·936 | 45·9 | 31·1 | WSW |
| 3 | 29·887 | 29·962 | 30·007 | 30·065 | 38·9 | 30·8 | N | 3 | 30·014 | 30·076 | 30·056 | 30·020 | 37·6 | 30·6 | NNW |
| 4 | 30·005 | 29·910 | 29·863 | 29·929 | 40·9 | 29·1 | NW | 4 | 29·905 | 29·855 | 29·853 | 29·925 | 42·3 | 30·5 | NNW |
| 5 | 29·975 | 30·028 | 30·027 | 30·030 | 41·8 | 28·9 | NW | 5 | 29·929 | 29·919 | 29·813 | 29·765 | 42·6 | 26·8 | SSW |
| 6 | 29·976 | 30·012 | 30·030 | 30·096 | 47·7 | 33·1 | NW | 6 | 29·788 | 29·820 | 29·790 | 29·822 | 48·5 | 37·0 | SW |
| 7 | 30·086 | 30·079 | 29·993 | 29·934 | 49·4 | 35·7 | SW | 7 | 29·701 | 29·605 | 29·561 | 29·555 | 45·8 | 41·7 | S |
| 8 | 29·874 | 29·792 | 29·699 | 29·640 | 49·3 | 43·3 | SW | 8 | 29·456 | 29·344 | 29·206 | 29·120 | 51·3 | 44·9 | SSE |
| 9 | 29·471 | 29·455 | 29·355 | 29·306 | 52·3 | 47·6 | SW | 9 | 28·956 | 28·928 | 28·830 | 28·824 | 49·7 | 45·0 | SSE |
| 10 | 29·285 | 29·342 | 29·393 | 29·459 | 55·3 | 46·9 | W | 10 | 28·971 | 29·109 | 29·209 | 29·263 | 49·9 | 39·7 | SSW |
| 11 | 29·265 | 28·918 | 28·779 | 29·060 | 47·8 | 39·8 | SW | 11 | 29·203 | 29·065 | 29·089 | 29·211 | 40·4 | 33·9 | NE |
| 12 | 29·146 | 29·263 | 29·343 | 29·472 | 41 7 | 32·1 | NW | 12 | 29·318 | 29·430 | 29·506 | 29·590 | 34·0 | 30·8 | ENE |
| 13 | 29·550 | 29·634 | 29·601 | 29·494 | 33·2 | 31·9 | E | 13 | 29·614 | 29·610 | 29·520 | 29·426 | 34·9 | 28·3 | ESE |
| 14 | 29·308 | 29·249 | 29·187 | 29·216 | 50·3 | 32·3 | SW | 14 | 29·288 | 29·228 | 29·170 | 29·184 | 35·7 | 29·0 | ESE |
| 15 | 29·187 | 29·194 | 29·211 | 29·239 | 49·0 | 37·3 | WSW | 15 | 29·201 | 29·275 | 29·345 | 29·477 | 34·5 | 29·8 | NE |
| 16 | 29·269 | 29·379 | 29·460 | 29·574 | 37·8 | 30·9 | N | 16 | 29·595 | 29 715 | 29·793 | 29·871 | 33·0 | 27·9 | NE |
| 17 | 29·628 | 29·765 | 29·879 | 30·016 | 36·1 | 29·9 | N | 17 | 29·922 | 29·994 | 30·042 | 30·170 | 35·1 | 22·4 | WNW |
| 18 | 30·080 | 30·164 | 30·159 | 30·158 | 34·3 | 30·4 | NE | 18 | 30·246 | 30·346 | 30·370 | 30·410 | 38·8 | 26·7 | NE |
| 19 | 30·060 | 30·039 | 29·946 | 29·932 | 34·9 | 29·1 | NE | 19 | 30·401 | 30·405 | 30 ·07 | 30·259 | 38·0 | 30·7 | NE |
| 20 | 29 915 | 29·957 | 30·018 | 30·116 | 34·5 | 30·6 | NNE | 20 | 30·243 | 30·267 | 30·301 | 30·397 | 40·8 | 30 0 | NNE |
| 21 | 30·149 | 30·210 | 30·191 | 30·217 | 45·6 | 30·7 | NE | 21 | 30·403 | 30·355 | 30·237 | 30·111 | 44·4 | 28·3 | WSW |
| 22 | 30·109 | 29·977 | 29·774 | 29·641 | 47·2 | 28·3 | WSW | 22 | 29·869 | 29·741 | 29·667 | 29·605 | 45·3 | 37·5 | NE |
| 23 | 29·428 | 29·317 | 29·285 | 29·304 | 43·1 | 36·9 | N | 23 | 29·510 | 29·466 | 29·370 | 29·322 | 38·9 | 33·0 | NW |
| 24 | 29·331 | 29·417 | 29·356 | 29·228 | 47·0 | 35·0 | ENE | 24 | 29·262 | 29·266 | 29·358 | 29·358 | 38·5 | 32·9 | E |
| 25 | 29·120 | 29·106 | 29·092 | 28·969 | 43·9 | 34·7 | W | 25 | 29·221 | 29·079 | 28·947 | 28·923 | 36·0 | 30·4 | WNW |
| 26 | 29·056 | 29·056 | 29·071 | 29·042 | 41·8 | 32·4 | SW | 26 | 28·919 | 28·979 | 28·977 | 28·969 | 41·2 | 27·9 | NNW |
| 27 | 29·249 | 29·043 | 29·015 | 29·045 | 42·3 | 33·1 | NW | 27 | 28·889 | 28·819 | 28·799 | 28·877 | 40·2 | 30·4 | WSW |
| 28 | 28·919 | 28·771 | 28·719 | 28·796 | 52 5 | 33·1 | SE | 28 | 28·913 | 28·916 | 28·880 | 28·846 | 37·4 | 30·0 | ENE |
| 29 | 28·833 | 28·860 | 28·880 | 28·967 | 51·8 | 39·0 | ESE | 29 | 28·860 | 28·944 | 29·032 | 29·100 | 39·7 | 33·9 | NE |
| 30 | 29·080 | 29·228 | 29·333 | 29·473 | 48·3 | 38·2 | WSW | 30 | 29·183 | 29·305 | 29·409 | 29·569 | 45·0 | 38·4 | NNW |
| 31 | 29·609 | 29·743 | 29·835 | 29·922 | 44·9 | 37·7 | N | 31 | 29·708 | 29·822 | 29·886 | 30·016 | 45·0 | 34·1 | NNW |

## APRIL, 1888.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29·975 | 30·026 | 30·008 | 30·013 | 47·1 | 34·0 | N | 1 | 30·035 | 30·024 | 29·939 | 29·876 | 46·0 | 31·2 | WSW |
| 2 | 29·930 | 29·837 | 29·730 | 29·767 | 47·7 | 31·8 | WNW | 2 | 29·786 | 29·816 | 29·853 | 29·986 | 45·3 | 34·0 | NNE |
| 3 | 29·816 | 29·862 | 29·853 | 29·881 | 42·8 | 31·8 | N | 3 | 30·015 | 30·026 | 29·936 | 29·839 | 42·3 | 31·0 | WNW |
| 4 | 29·788 | 29·767 | 29·775 | 29·875 | 42·4 | 30·6 | N | 4 | 29·731 | 29·774 | 29·852 | 30·000 | 44·5 | 32·5 | N |
| 5 | 29·959 | 30·042 | 30·083 | 30·196 | 43·3 | 31·6 | NE | 5 | 30·030 | 30·150 | 30·146 | 30·196 | 46·1 | 31·8 | NW |
| 6 | 30·224 | 30·242 | 30·201 | 30·242 | 44·8 | 28·3 | N | 6 | 30·208 | 30·246 | 30·223 | 30·241 | 45·8 | 33·7 | S |
| 7 | 30·229 | 30·206 | 30·092 | 30·050 | 45·3 | 28·6 | N | 7 | 30·222 | 30·199 | 30·131 | 30·152 | 49·2 | 31·9 | NE |
| 8 | 29·976 | 29·955 | 29·960 | 30·017 | 40·6 | 31·7 | NE | 8 | 30·130 | 30·129 | 30·048 | 30·060 | 45·6 | 34·0 | SE |
| 9 | 29·997 | 29·992 | 29·920 | 29·931 | 43·0 | 31·3 | NNW | 9 | 30·044 | 30·020 | 29·968 | 30·004 | 49·7 | 29·7 | NNW |
| 10 | 29·977 | 30·043 | 30·065 | 30·074 | 41·8 | 31·3 | N | 10 | 30·016 | 30·015 | 29·939 | 29·853 | 49·0 | 38·9 | W |
| 11 | 29·960 | 29·869 | 29·820 | 29·861 | 52·0 | 37·7 | NW | 11 | 29·791 | 29·761 | 29·769 | 29·775 | 47·3 | 38·9 | WSW |
| 12 | 29·829 | 29·812 | 29·783 | 29·794 | 48·0 | 39·1 | N W | 12 | 29·726 | 29·710 | 29·633 | 29·434 | 45·9 | 35·5 | SSW |
| 13 | 29·729 | 29·750 | 29·770 | 29·869 | 60·2 | 42·3 | WNW | 13 | 29·382 | 29·418 | 29·575 | 29·631 | 48·2 | 42·7 | WSW |
| 14 | 29·899 | 29·936 | 29·903 | 29·884 | 59·9 | 42·1 | W | 14 | 29·616 | 29·690 | 29·734 | 29·773 | 56·0 | 42·7 | WSW |
| 15 | 29·812 | 29·732 | 29·687 | 29·737 | 64·5 | 40·6 | E | 15 | 29·736 | 29·675 | 29·623 | 29·617 | 49·8 | 44·1 | SSE |
| 16 | 29·816 | 29·923 | 29·905 | 29·896 | 58·1 | 42·0 | W | 16 | 29·619 | 29·643 | 29·637 | 29·602 | 54·5 | 39·4 | WSW |
| 17 | 29·783 | 29·720 | 29·655 | 29·655 | 56·8 | 45·2 | SW | 17 | 29·486 | 29·394 | 29·339 | 29·372 | 51·8 | 45·6 | SSW |
| 18 | 29·620 | 29·633 | 29·633 | 29·630 | 55·3 | 43·9 | SW | 18 | 29·359 | 29·364 | 29·344 | 29·353 | 50·0 | 41·0 | SSW |
| 19 | 29·599 | 29·571 | 29·536 | 29·557 | 53·8 | 41·9 | SSW | 19 | 29·388 | 29·478 | 29·501 | 29·536 | 53·0 | 43·0 | ESE |
| 20 | 29·534 | 29·547 | 29·529 | 29·595 | 51·0 | 43·5 | W | 20 | 29·571 | 29·630 | 29·784 | 29·881 | 44·6 | 37·1 | NE |
| 21 | 29·630 | 29·695 | 29·689 | 29·702 | 55·0 | 37·3 | SW | 21 | 29·879 | 29·889 | 29·869 | 29·883 | 44·7 | 34·6 | E |
| 22 | 29·649 | 29·649 | 29·648 | 29·693 | 48·2 | 40·5 | E | 22 | 29·847 | 29·879 | 29·901 | 29·956 | 44·0 | 33·0 | E |
| 23 | 29·669 | 29·706 | 29·695 | 29·728 | 47·7 | 41·3 | NE | 23 | 29·961 | 29·993 | 30·036 | 30·119 | 43·0 | 36·0 | ENE |
| 24 | 29·744 | 29·834 | 29·891 | 29·934 | 46·9 | 39·0 | NE | 24 | 30·121 | 30·150 | 30·162 | 30·207 | 44·3 | 36·0 | ENE |
| 25 | 29·943 | 29·967 | 29·994 | 30·087 | 49·3 | 38·2 | NE | 25 | 30·211 | 30·225 | 30·231 | 30·274 | 48·6 | 35·2 | ESE |
| 26 | 30·095 | 30·145 | 30·177 | 30·237 | 45·6 | 34·1 | NNE | 26 | 30·255 | 30·222 | 30·139 | 30·062 | 52·9 | 35·7 | W |
| 27 | 30·197 | 30·110 | 30·013 | 30·026 | 56·2 | 31·3 | W | 27 | 29·854 | 29·812 | 29·822 | 29·865 | 52·7 | 41·0 | WNW |
| 28 | 30·015 | 30·031 | 29·959 | 29·927 | 59·2 | 46·8 | SW | 28 | 29·829 | 29·723 | 29·576 | 29·466 | 52·0 | 40·9 | WSW |
| 29 | 29·857 | 29·819 | 29·768 | 29·775 | 54·3 | 43·4 | SW | 29 | 29·375 | 29·373 | 29·435 | 29·470 | 50·9 | 40·7 | W |
| 30 | 29·714 | 29·651 | 29·534 | 29·466 | 62·0 | 41·9 | SW | 30 | 29·438 | 29·414 | 29·346 | 29·253 | 49·7 | 40·9 | ENE |

## BAROMETER READINGS, &c.

### MAY, 1888.

| KEW. | | | | | | | | GLASGOW. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer. | | | | Temperature. | | | | Barometer. | | | | Temperature. | | |
| Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | Direction of wind at noon | Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | Direction of wind at noon |
| 1 | 29·377 | 29·377 | 29·497 | 29·762 | 55·6 | 44·3 | SW | 1 | 29·095 | 29·015 | 29·053 | 29·374 | 51·5 | 42·1 | SW |
| 2 | 29·860 | 29·832 | 29·693 | 29·714 | 53·9 | 40·3 | SW | 2 | 29·466 | 29·226 | 29·171 | 29·080 | 54·3 | 39·2 | SW |
| 3 | 29·721 | 29·822 | 29·936 | 30·039 | 54·3 | 41·9 | W | 3 | 28·945 | 29·254 | 29·578 | 29·761 | 51·0 | 40·3 | WNW |
| 4 | 30·088 | 30·165 | 30·177 | 30·247 | 56·7 | 39·9 | W | 4 | 29·888 | 29·974 | 29·996 | 29·979 | 50·5 | 37·5 | WNW |
| 5 | 30·249 | 30·270 | 30·276 | 30·316 | 56·3 | 38·1 | W | 5 | 29·902 | 29·969 | 30·022 | 30·092 | 50·0 | 41·5 | WNW |
| 6 | 30·305 | 30·308 | 30·268 | 30·262 | 56·3 | 41·9 | SW | 6 | 30·075 | 30 068 | 30·053 | 30·044 | 54·2 | 44·6 | WSW |
| 7 | 30·248 | 30 255 | 30·216 | 30·216 | 66·2 | 50·2 | WSW | 7 | 29·994 | 29·989 | 29 962 | 29·931 | 55·5 | 49·9 | WSW |
| 8 | 30·182 | 30·185 | 30·169 | 30·244 | 67·3 | 50·0 | W | 8 | 29·891 | 30·012 | 30·112 | 30·197 | 50·9 | 39·3 | NW |
| 9 | 30·292 | 30·323 | 30·302 | 30·342 | 56·9 | 42·2 | N | 9 | 30·236 | 30·298 | 30·296 | 30·318 | 53·9 | 36·3 | NW |
| 10 | 30·343 | 30·364 | 30·339 | 30·415 | 56·4 | 41·1 | NE | 10 | 30·318 | 30·355 | 30·356 | 30·404 | 55·7 | 36·9 | E |
| 11 | 30·442 | 30·455 | 30·395 | 30·419 | 56·4 | 36·1 | NE | 11 | 30·431 | 30·433 | 30·382 | 30·375 | 61·0 | 36·6 | NNW |
| 12 | 30·415 | 30·430 | 30·346 | 30·337 | 60·7 | 34·3 | ESE | 12 | 30·369 | 30·355 | 30 299 | 30·283 | 57·0 | 37·2 | WNW |
| 13 | 30·273 | 30·171 | 30·002 | 29·938 | 68·4 | 39·6 | W | 13 | 30·168 | 30·022 | 29·927 | 29 913 | 55·1 | 42·0 | WNW |
| 14 | 29·875 | 29·839 | 29·797 | 29·778 | 54·9 | 32·1 | N | 14 | 29·891 | 29·849 | 29·738 | 29·663 | 52·8 | 38·9 | NW |
| 15 | 29·735 | 29·667 | 29·576 | 29·575 | 61·3 | 39·1 | SSE | 15 | 29·567 | 29·492 | 29·451 | 29·479 | 51·3 | 40·6 | W |
| 16 | 29·536 | 29·537 | 29·513 | 29·504 | ?62·7 | 42·4 | S | 16 | 29·479 | 29·430 | 29·361 | 29·264 | 50·9 | 42·5 | SE |
| 17 | 29·545 | 29·582 | 29·587 | 29·666 | 59·7 | 50·9 | S | 17 | 29·188 | 29·251 | 29·262 | 29·357 | 60·1 | 45·4 | SSW |
| 18 | 29·723 | 29·746 | 29·681 | 29·689 | 73·7 | 55·4 | ESE | 18 | 29·457 | 29·543 | 29·557 | 29·564 | 62·0 | 46·8 | SSE |
| 19 | 29·667 | 29·682 | 29·667 | 29·831 | 73·8 | 51·9 | S | 19 | 29·571 | 29·566 | 29·504 | 29·622 | 67·4 | 55·7 | NE |
| 20 | 30·017 | 30·164 | 30·219 | 30·322 | 64·6 | 47·2 | WSW | 20 | 29·776 | 29·923 | 30·072 | 30·228 | 59·7 | 46·4 | WSW |
| 21 | 30·359 | 30·405 | 30·359 | 30·407 | 66·1 | 44·3 | N | 21 | 30·310 | 30·364 | 30·386 | 30·456 | 65·7 | 43·0 | WSW |
| 22 | 30·387 | 30·357 | 30·323 | 30·342 | 55·7 | 45·0 | NNE | 22 | 30·484 | 30·485 | 30·458 | 30·502 | 64·3 | 45·6 | ESE |
| 23 | 30·336 | 30·345 | 30·328 | 30·340 | 64·5 | 44·7 | NE | 23 | 30·489 | 30·487 | 30·441 | 30 481 | 68·7 | 49·3 | ESE |
| 24 | 30·336 | 30·333 | 30·238 | 30·268 | 67·3 | 42·9 | ENE | 24 | 30·468 | 30·440 | 30·376 | 30·382 | 65·1 | 44·6 | ESE |
| 25 | 30·244 | 30·222 | 30·136 | 30·159 | 60·5 | 42·8 | NE | 25 | 30·325 | 30·261 | 30·157 | 30·173 | 67·1 | 42·7 | NNE |
| 26 | 30·117 | 30·104 | 30·042 | 30·017 | 55·1 | 43·0 | NE | 26 | 30·143 | 30·097 | 29·968 | 29·917 | 62·4 | 42·7 | NE |
| 27 | 29·956 | 29·873 | 29·761 | 29·717 | 62·9 | 38·3 | S | 27 | 29 819 | 29·743 | 29·713 | 29·753 | 54·4 | 41·3 | NE |
| 28 | 29·704 | 29·706 | 29 756 | 29·873 | 58·2 | 40·2 | NNE | 28 | 29·782 | 29·833 | 29·852 | 29·912 | 54·2 | 39·8 | ESE |
| 29 | 29·911 | 29·948 | 29·908 | 29·821 | 60·0 | 46·4 | SE | 29 | 29·914 | 29·862 | 29·740 | 29·527 | 51·0 | 38·7 | SE |
| 30 | 29·690 | 29·691 | 29·712 | 29·825 | 62·9 | 49·8 | SW | 30 | 29·264 | 29·211 | 29·260 | 29·389 | 55·3 | 47·1 | SW |
| 31 | 29·869 | 29·908 | 29·954 | 30·091 | 63·2 | 47·0 | W | 31 | 29·407 | 29·514 | 29·714 | 29·871 | 51·5 | 43·7 | WNW |

### JUNE, 1888.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30·148 | 30·207 | 30·201 | 30·230 | 66·3 | 47·1 | WNW | 1 | 29·975 | 30·101 | 30·148 | 30·192 | 54·6 | 41·7 | NW |
| 2 | 30·189 | 30·163 | 30·037 | 29·981 | 75·7 | 51·8 | S | 2 | 30·189 | 30·176 | 30·076 | 30·001 | 45·0 | 40·4 | ENE |
| 3 | 29·859 | 29·831 | 29·866 | 29·975 | 77·9 | 53·0 | SW | 3 | 29·852 | 29·773 | 29·759 | 29·811 | 45·1 | 40·6 | E |
| 4 | 30·018 | 30·041 | 30·000 | 30·079 | 73·8 | 51·4 | SW | 4 | 29·869 | 30·004 | 30·091 | 30·188 | 54·4 | 40 5 | NE |
| 5 | 30·098 | 30·083 | 30·068 | 30·014 | 55·5 | 48·3 | E | 5 | 30·211 | 30·184 | 30·116 | 30·113 | 55·3 | 38·1 | ENE |
| 6 | 29·871 | 29·841 | 29·833 | 29·835 | 60·2 | 48·0 | E | 6 | 30·018 | 29·968 | 29·911 | 29·824 | 50·4 | 41·7 | ESE |
| 7 | 29·823 | 29·818 | 29·791 | 29·802 | 68·0 | 45·3 | SW | 7 | 29·750 | 29·696 | 29·638 | 29·642 | 54·7 | 44·2 | E |
| 8 | 29·759 | 29·712 | 29·624 | 29·610 | 67·0 | 53·0 | S | 8 | 29·622 | 29·590 | 29·559 | 29·559 | 57·0 | 47·2 | ENE |
| 9 | 29·549 | 29·535 | 29·603 | 29·787 | 64·9 | 54·6 | SSE | 9 | 29·535 | 29·518 | 29·511 | 29·605 | 63·1 | 48·3 | NNW |
| 10 | 29·899 | 30·005 | 30·061 | 30·102 | 66·7 | 51·0 | WNW | 10 | 29·678 | 29·786 | 29·896 | 29·978 | 55·8 | 46·2 | WNW |
| 11 | 30·091 | 30·071 | 29·993 | 29·961 | 68·9 | 47·6 | S | 11 | 29·947 | 29·877 | 29·805 | 29·674 | 61·2 | 44·9 | SW |
| 12 | 29·849 | 29·730 | 29·655 | 29·722 | 72·3 | 51·7 | S | 12 | 29·529 | 29·451 | 29·368 | 29·450 | 56·8 | 47·8 | SSE |
| 13 | 29·762 | 29·797 | 29·803 | 29·852 | 66·0 | 48·1 | SW | 13 | 29·517 | 29·627 | 29·658 | 29·738 | 61·1 | 47·2 | W |
| 14 | 29·859 | 29·895 | 29·931 | 29·985 | 60·9 | 48·5 | WNW | 14 | 29·792 | 29·827 | 29·847 | 29·875 | 64·6 | 43·0 | W |
| 15 | 29·983 | 29·985 | 29·842 | 29·745 | 56·5 | 48·0 | SW | 15 | 29·836 | 29·807 | 29·842 | 29·930 | 61·5 | 49·5 | NE |
| 16 | 29·790 | 29·871 | 29·913 | 30·007 | 61·2 | 49·2 | N | 16 | 29·964 | 30·044 | 30·050 | 30·088 | 64·7 | 48 4 | ESE |
| 17 | 30·008? | 30·048 | 30·088? | 30·131 | 52·9 | 44·4 | N | 17 | 30·087 | 30·076 | 30·030 | 30·126 | 72·2 | 46·5 | WNW |
| 18 | 30·118? | 30·160 | 30·162 | 30·202 | 55·3 | 45·0 | N | 18 | 30·175 | 30·209 | 30·233 | 30·307 | 63·8 | 46·9 | ESE |
| 19 | 30·189 | 30·169 | 30·115 | 30·079 | 53·1 | 46·2 | N | 19 | 30·304 | 30·259 | 30·195 | 30·211 | 64·0 | 45·6 | ESE |
| 20 | 30·005 | 29·962 | 29·872 | 29·906 | 54·1 | 45·4 | N | 20 | 30·175 | 30·180 | 30·093 | 30·128 | 65·0 | 47·6 | SE |
| 21 | 29·910 | 29·943 | 29·918 | 29·936 | 64·1 | 49·0 | NNE | 21 | 30·135 | 30·161 | 30·160 | 30·198 | 65·1 | 48·9 | SE |
| 22 | 29·950 | 30·032 | 30·044 | 30·104 | 68·7 | 54·7 | N | 22 | 30·189 | 30·228 | 30·207 | 30·284 | 61·1 | 48·0 | ESE |
| 23 | 30·125 | 30·125 | 30·081 | 30·055 | 65·5 | 51·3 | NNE | 23 | 30·298 | 30·292 | 30·250 | 30·247 | 66·8 | 46·6 | E |
| 24 | 29·973 | 29·961 | 29·935 | 29·972 | 75·2 | 51·9 | NE | 24 | 30·223 | 30·178 | 30·102 | 30·099 | 64·3 | 46·4 | E |
| 25 | 29·982 | 29·956 | 29·906 | 29·897 | 82·0 | 60·9 | E | 25 | 30·086 | 30·067 | 29·998 | 29·990 | 69·9 | 49·3 | ESE |
| 26 | 29·840 | 29·825 | 29·769 | 29·779 | 73·4 | 59·8 | NE | 26 | 29·951 | 29·888 | 29·789 | 29·763 | 73·4 | 51·0 | ESE |
| 27 | 29·745 | 29·718 | 29·639 | 29·565 | 67·4 | 56·4 | S | 27 | 29·691 | 29·636 | 29·555 | 29·541 | 68·2 | 52·1 | E |
| 28 | 29·587 | 29·558 | 29·566 | 29·603 | 65·0 | 53·2 | SW | 28 | 29·475 | 29·461 | 29·434 | 29·456 | 59·0 | 53·7 | ESE |
| 29 | 29·564 | 29·532 | 29·502 | 29·547 | 64·0 | 52·2 | W | 29 | 29·467 | 29·512 | 29 508 | 29·580 | 64·2 | 49·3 | E |
| 30 | 29·614 | 29·655 | 29·721 | 29·852 | 62·7 | 47·8 | N | 30 | 29·640 | 29·707 | 29·740 | 29·858 | 66·7 | 43·9 | NNE |

# BAROMETER READINGS, &c.

## JULY, 1888.

| KEW. | | | | | | | | GLASGOW. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer. | | | | Temperature. | | | | Barometer. | | | | Temperature. | | |
| Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | Direction of wind at noon | Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | Direction of wind at noon |
| 1 | 29·916 | 30·004 | 30·008 | 30·025 | 65·3 | 44·2 | NNW | 1 | 29·911 | 29·936 | 29·906 | 29·913 | 64·7 | 42·0 | WSW |
| 2 | 30·005 | 29·942 | 29·759 | 29·603 | 58·1 | 52·1 | S | 2 | 29·820 | 29·686 | 29·441 | 29·227 | 55·3 | 48·2 | ESE |
| 3 | 29·560 | 29·564 | 29·547 | 29·565 | 67·2 | 55·3 | WSW | 3 | 29·183 | 29·257 | 29·330 | 29·330 | 52·9 | 50·5 | ENE |
| 4 | 29·529 | 29·477 | 29·460 | 29·461 | 64·9 | 53·1 | SSW | 4 | 29·286 | 29·285 | 29·295 | 29·340 | 57·3 | 49·8 | E |
| 5 | 29·448 | 29·461 | 29·456 | 29·516 | 64·9 | 52·5 | SW | 5 | 29·381 | 29·450 | 29·499 | 29·606 | 56·4 | 47·2 | ESE |
| 6 | 29·538 | 29·621 | 29·710 | 29·809 | 62·1 | 51·9 | N | 6 | 29·659 | 29·748 | 29·775 | 29·837 | 55·0 | 46·5 | ESE |
| 7 | 29·856 | 29·940 | 29·975 | 30·039 | 57·1 | 51·0 | NE | 7 | 29·885 | 29·927 | 29·934 | 29·964 | 59·4 | 44·6 | SW |
| 8 | 30·044 | 30·054 | 30·026 | 30·051 | 66·0 | 51·0 | SE | 8 | 29·955 | 29·923 | 29·881 | 29·836 | 58·4 | 42·4 | W |
| 9 | 30·019 | 29·966 | 29·883 | 29·853 | 64·6 | 49·9 | SW | 9 | 29·714 | 29·644 | 29·703 | 29·800 | 59·9 | 46·7 | WNW |
| 10 | 29·892 | 29·925 | 29·861 | 29·771 | 63·2 | 49·0 | W | 10 | 29·869 | 29·810 | 29·647 | 29·726 | 55·2 | 44·5 | W |
| 11 | 29·622 | 29·688 | 29·823 | 29·907 | 55·0 | 43·6 | NW | 11 | 29·753 | 29·800 | 29·843 | 29·907 | 61·2 | 44·8 | NE |
| 12 | 29·945 | 30·008 | 30·065 | 30·088 | 54·0 | 48·1 | NNW | 12 | 29·930 | 29·972 | 29·980 | 30·012 | 63·5 | 47·0 | W |
| 13 | 30·098 | 30·102 | 30·032 | 30·036 | 68·3 | 44·5 | WNW | 13 | 30·002 | 29·979 | 29·970 | 29·970 | 63·6 | 50·0 | WNW |
| 14 | 30·011 | 29·999 | 29·930 | 29·878 | 68·5 | 53·9 | NW | 14 | 29·937 | 29·927 | 29·894 | 29·865 | 61·8 | 54·0 | WSW |
| 15 | 29·838? | 29·793 | 29·690? | 29·596 | 58·1 | 55·1 | ENE | 15 | 29·816 | 29·774 | 29·688 | 29·658 | 57·2 | 53·8 | E |
| 16 | 29·498? | 29·430 | 29·403 | 29·425 | 66·3 | 49·9 | SE | 16 | 29·587 | 29·543 | 29·488 | 29·490 | 55·4 | 49·2 | E |
| 17 | 29·426 | 29·434 | 29·406 | 29·430 | 68·0 | 48·9 | NW | 17 | 29·490 | 29·470 | 29·480 | 29·575 | 57·7 | 50·7 | ENE |
| 18 | 29·420 | 29·490 | 29·557 | 29·665 | 66·2 | 56·3 | SW | 18 | 29·590 | 29·668 | 29·714 | 29·818 | 68·1 | 53·1 | E |
| 19 | 29·727 | 29·808 | 29·824 | 29·874 | 69·8 | 54·5 | N | 19 | 29·847 | 29·842 | 29·800 | 29·805 | 71·6 | 53·2 | ESE |
| 20 | 29·867 | 29·900 | 29·874 | 29·873 | 66·2 | 50·9 | SW | 20 | 29·783 | 29·787 | 29·766 | 29·745 | 63·8 | 53·7 | WSW |
| 21 | 29·846 | 29·883 | 29·899 | 29·874 | 65·0 | 55·6 | SW | 21 | 29·707 | 29·707 | 29·693 | 29·681 | 64·6 | 53·5 | WSW |
| 22 | 29·848 | 29·839 | 29·781 | 29·672 | 71·3 | 56·6 | SW | 22 | 29·649 | 29·609 | 29·573 | 29·541 | 64·9 | 50·3 | ESE |
| 23 | 29·569 | 29·588 | 29·573 | 29·645 | 66·9 | 55·3 | SSW | 23 | 29·417 | 29·367 | 29 335 | 29·3 6 | 64·7 | 54·0 | SW |
| 24 | 29·671 | 29·702 | 29·737 | 29·791 | 67·7 | 55·1 | SW | 24 | 29·332 | 29·347 | 29·383 | 29·463 | 66·3 | 53·5 | WSW |
| 25 | 29·764 | 29·702 | 29·605 | 29·567 | 62·9 | 56·9 | S | 25 | 29·470 | 29·473 | 29·430 | 29·420 | 63 4 | 53·0 | WSW |
| 26 | 29·637 | 29·711 | 29·769 | 29·847 | 68·7 | 53·7 | SW | 26 | 29·434 | 29·482 | 29·534 | 29·612 | 61·6 | 52·0 | WSW |
| 27 | 29·854 | 29·831 | 29·660 | 29·467 | 67·2 | 50·2 | SSE | 27 | 29·651 | 29·681 | 29·645 | 29·657 | 63·4 | 47·5 | ENE |
| 28 | 29·358 | 29·469 | 29·631 | 29·756 | 65·1 | 56·1 | NW | 28 | 29·650 | 29·700 | 29·732 | 29·763 | 52·1 | 48·9 | ESE |
| 29 | 29·772 | 29·790 | 29·702 | 29·603 | 66·3 | 53·3 | SW | 29 | 29·741 | 29·733 | 29·681 | 29·681 | 55·4 | 47·8 | E |
| 30 | 29·506 | 29·458 | 29·411 | 29·508 | 68·4 | 51·4 | SW | 30 | 29·643 | 29·636 | 29·621 | 29·674 | 57·4 | 45·3 | ESE |
| 31 | 29·648 | 29·803 | 29·877 | 29·934 | 59·0 | 50·7 | NNE | 31 | 29·718 | 29·769 | 29·807 | 29·877 | 60·0 | 41·8 | WNW |

## AUGUST, 1888.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29·918 | 29·938 | 29·929 | 29·967 | 57·2 | 51·0 | NNE | 1 | 29·914 | 29·957 | 29·973 | 30·014 | 61·4 | 42·8 | N |
| 2 | 29·992 | 30·087 | 30·121 | 30·197 | 65·4 | 50·0 | N | 2 | 30·047 | 30·071 | 30·080 | 30·108 | 61·9 | 41·5 | W |
| 3 | 30·220 | 30·224 | 30·194 | 30·199 | 68·3 | 44·1 | SW | 3 | 30·074 | 30·018 | 29·924 | 29·945 | 59·5 | 48·5 | WSW |
| 4 | 30·147 | 30·103 | 29·999 | 29·874 | 67·1 | 51·9 | SW | 4 | 29·934 | 29·855 | 29·748 | 29·701 | 60·4 | 48·4 | W |
| 5 | 29·665 | 29·793 | 29·934 | 30·069 | 62·0 | 52·3 | NW | 5 | 29·710 | 29·861 | 29·949 | 30·029 | 63·6 | 48·3 | N |
| 6 | 30·118 | 30·135 | 30·091 | 30·105 | 58·8 | 47·6 | W | 6 | 30·015 | 29·994 | 29·970 | 29·948 | 54·5 | 47·9 | W |
| 7 | 30·090 | 30·121 | 30·070 | 30·107 | 77·1 | 56·0 | SW | 7 | 29·912 | 29·857 | 29·793 | 29·833 | 60·7 | 53·5 | WSW |
| 8 | 30·102 | 30·126 | 30·101 | 30·128 | 77·2 | 59·0 | SW | 8 | 29·826 | 29·843 | 29·893 | 29·952 | 64·4 | 53·2 | WSW |
| 9 | 30·100 | 30·094 | 30·075 | 30·041 | 78·8 | 54·8 | S | 9 | 29·962 | 30·001 | 29·980 | 30·000 | 64·3 | 53·2 | W |
| 10 | 29·994 | 29·991 | 29·984 | 30·052 | 79·7 | 58·9 | S | 10 | 30·004 | 30·019 | 30·015 | 30·086 | 58·9 | 52·9 | E |
| 11 | 30·054 | 30·067 | 30·058 | 30·056 | 66·1 | 55·1 | SW | 11 | 30·052 | 30·043 | 29·967 | 29·905 | 55·2 | 50·4 | ESE |
| 12 | 30·006 | 29·957 | 29·861 | 29·819 | 70·5 | 56·9 | S | 12 | 29·787 | 29·685 | 29·591 | 29·438 | 65·6 | 54·8 | WSW |
| 13 | 29·767 | 29·833 | 29·922 | 30·045 | 66·9 | 51·3 | W | 13 | 29·296 | 29·463 | 29·630 | 29·835 | 60·0 | 48·0 | WNW |
| 14 | 30·123 | 30·192 | 30·168 | 30·170 | 66·0 | 47·1 | WNW | 14 | 29·936 | 30·024 | 30·056 | 30·102 | 60·2 | 44·8 | WNW |
| 15 | 30·115 | 30·081 | 30·018 | 30·054 | 61·3 | 46·0 | ENE | 15 | 30·102 | 30·107 | 30·086 | 30·145 | 64·3 | 48·0 | ENE |
| 16 | 30·075 | 30·119 | 30·104 | 30·147 | 59·9 | 44·8 | NNE | 16 | 30·165 | 30·193 | 30·161 | 30·217 | 60·0 | 44·3 | NE |
| 17 | 30·116 | 30·118 | 30·066 | 30·155 | 59·0 | 48·8 | N | 17 | 30·217 | 30·222 | 30·170 | 30·212 | 59·8 | 47·3 | ESE |
| 18 | 30·169 | 30·224 | 30·228 | 30·264 | 63·1 | 48·8 | N | 18 | 30·223 | 30·223 | 30·179 | 30·180 | 62·0 | 47·2 | W |
| 19 | 30·238 | 30·202 | 30·117 | 30·078 | 66·3 | 43·4 | S | 19 | 30·132 | 30·081 | 29·979 | 29·929 | 64·4 | 44·3 | SSW |
| 20 | 30·005 | 29·950 | 29·848 | 29·748 | 63·3 | 52·9 | SE | 20 | 29·831 | 29·787 | 29·719 | 29·668 | 58·5 | 51·7 | S |
| 21 | 29·623 | 29·612 | 29·613 | 29·628 | * | 55·1 | W | 21 | 29·574 | 29·556 | 29·515 | 29·530 | 56·1 | 54·1 | ENE |
| 22 | 29·662 | 29·759 | 29·847 | 29·944 | 68·8 | 52·1 | P | 22 | 29·543 | 29·624 | 29·679 | 29·719 | 63·7 | 52·5 | WSW |
| 23 | 29·928 | 29·893 | 29·853 | 29·776 | 65·1 | 50·2 | SSW | 23 | 29·669 | 29·580 | 29·502 | 29·382 | 61·6 | 52·5 | SSW |
| 24 | 29·680 | 29·618 | 29·589 | 29·592 | 71·6 | 54·2 | S | 24 | 29·372 | 29·422 | 29·390 | 29·434 | 65·0 | 54·5 | S |
| 25 | 29·618 | 29·698 | 29·766 | 29·858 | 68·3 | 53·1 | SW | 25 | 29·489 | 29·583 | 29·607 | 29·635 | 64·6 | 53·1 | WSW |
| 26 | 29·906 | 29·931 | 29·919 | 29·959 | 65·6 | 52·6 | SW | 26 | 29·586 | 29·593 | 29·614 | 29·648 | 62·8 | 53·2 | WSW |
| 27 | 29·955 | 29·947 | 29·911 | 29·893 | 65·1 | 51·4 | SW | 27 | 29·567 | 29·595 | 29·564 | 29·559 | 59·9 | 51·2 | SW |
| 28 | 29·882 | 29·815 | 29·607 | 29·470 | 61·7 | 50·3 | SW | 28 | 29·534 | 29·541 | 29·487 | 29·507 | 60·0 | 49·6 | SW |
| 29 | 29·787 | 29·895 | 29·899 | 29·950 | 61·7 | 50·0 | WSW | 29 | 29·523 | 29·564 | 29·585 | 29·666 | 58·9 | 46·8 | WSW |
| 30 | 29·942 | 29·962 | 29·967 | 30·059 | 61·9 | 47·6 | SW | 30 | 29·686 | 29·739 | 29·817 | 29·957 | 57·0 | 47·3 | SW |
| 31 | 30·134 | 30·213 | 30·240 | 30·295 | 61·9 | 46·1 | NW | 31 | 30·062 | 30·159 | 30·184 | 30·197 | 59·1 | 43·4 | W |

* Record lost.

## BAROMETER READINGS, &c.

### SEPTEMBER, 1888.

| KEW. | | | | | | | | GLASGOW. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer. | | | | Temperature. | | Direction of wind at noon | | Barometer. | | | | Temperature. | | Direction of wind at noon |
| Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | | Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | |
| 1 | 30·307 | 30·291 | 30·232 | 30·197 | 64·1 | 42·3 | SW | 1 | 30·103 | 30·009 | 29·887 | 29·785 | 56·3 | 48·0 | SSW |
| 2 | 30·073 | 30·011 | 29·945 | 29·940 | 62·0 | 54·0 | SW | 2 | 29·745 | 29·800 | 29·829 | 29·874 | 59·9 | 51·1 | WSW |
| 3 | 29·907 | 29·938 | 29·901 | 29 939 | 68·0 | 54·2 | S | 3 | 29·846 | 29·841 | 29·786 | 29·744 | 57·9 | 48·3 | SW |
| 4 | 29·918 | 29·964 | 29·943 | 29·982 | 66·9 | 52·6 | SW | 4 | 29·634 | 29·699 | 29·734 | 29·758 | 58·7 | 49·0 | WSW |
| 5 | 29·988 | 30·050 | 30·068 | 30·089 | 64·2 | 57·9 | SW | 5 | 29·716 | 29·769 | 29·815 | 29·824 | 60·7 | 50·4 | WSW |
| 6 | 30·038 | 30·004 | 29·995 | 30·024 | 63·9 | 50·0 | SW | 6 | 29·765 | 29·663 | 29·627 | 29·719 | 56·1 | 48·9 | SW |
| 7 | 30·002 | 30·022 | 30·053 | 30·193 | 63·0 | * | WNW | 7 | 29·816 | 30·011 | 30·115 | 30·258 | 58·8 | 47·8 | ENE |
| 8 | 30·274 | 30·355 | 30·371 | 30·385 | 57·1 | * | N | 8 | 30·336 | 30·429 | 30·418 | 30·448 | 55·1 | 45·4 | WSW |
| 9 | 30·280 | 30·174 | 30·103 | 30·100 | 58·1 | 45·2 | NNE | 9 | 30·445 | 30·434 | 30·324 | 30·288 | 52·3 | 41·4 | ESE |
| 10 | 30·063 | 30·099 | 30·113 | 30·190 | 59·5 | 43·3 | NNW | 10 | 30·214 | 30·176 | 30·109 | 30·130 | 60·2 | 45·0 | WSW |
| 11 | 30·221 | 30·280 | 30·287 | 30·336 | 62·5 | 42·0 | W | 11 | 30·127 | 30·139 | 30·148 | 30·211 | 57·0 | 43·0 | W |
| 12 | 30·406 | 30·467 | 30·438 | 30·481 | 64·2 | 41·4 | NW | 12 | 30·248 | 30·…39 | 30·355 | 30·398 | 59·0 | 51·0 | WSW |
| 13 | 30·468 | 30·464 | 30·377 | 30·358 | 63·1 | 40·8 | E | 13 | 30·410 | 30·428 | 30·358 | 30·339 | 62·1 | 46·7 | SW |
| 14 | 30·265 | 30·229 | 30·155 | 30·157 | 65·1 | 50·3 | E | 14 | 30·284 | 30·238 | 30·131 | 30·113 | 64·0 | 47·7 | SSW |
| 15 | 30·120 | 30·140 | 30·088 | 30·100 | 71·0 | 50·6 | E | 15 | 30·050 | 29·998 | 29·953 | 30·016 | 58·0 | 48·8 | S |
| 16 | 30·098 | 30·168 | 30·181 | 30·219 | 61·0 | 55·0 | NNW | 16 | 30·087 | 30·171 | 30·183 | 30·212 | 58·7 | 45·4 | WNW |
| 17 | 30·211 | 30·234 | 30·211 | 30·243 | 63·2 | 53·8 | NNE | 17 | 30·195 | 30·207 | 30·195 | 30·228 | 58·5 | 46·0 | WNW |
| 18 | 30·234 | 30·263 | 30·239 | 30·262 | 60·8 | 52·0 | NNE | 18 | 30·236 | 30·275 | 30·256 | 30·279 | 62·9 | 46·2 | NW |
| 19 | 30·250 | 30·257 | 30·203 | 30·221 | 63·6 | 51·8 | ENE | 19 | 30·278 | 30·297 | 30·244 | 30·299 | 62·5 | 45·3 | E |
| 20 | 30·198 | 30·213 | 30·197 | 30·196 | 64·4 | 49·1 | ENE | 20 | 30·302 | 30·319 | 30·243 | 30·252 | 59·0 | 47·3 | E |
| 21 | 30·173 | 30·195 | 30·138 | 30·178 | 65·5 | 46·8 | N | 21 | 30·238 | 30·247 | 30·189 | 30·207 | 61·0 | 45·4 | WSW |
| 22 | 30·180 | 30·209 | 30·148 | 30·170 | 64·3 | 45·5 | N | 22 | 30·190 | 30·203 | 30·163 | 30·180 | 58·4 | 45·9 | WNW |
| 23 | 30·140 | 30·149 | 30·070 | 30·039 | 58·6 | 48·6 | NE | 23 | 30·152 | 30·160 | 30·080 | 30·066 | 56·4 | 43·9 | WSW |
| 24 | 29·955 | 29·931 | 29·857 | 29·890 | 67·2 | 52·0 | NE | 24 | 30·013 | 30·011 | 29·973 | 30·103 | 57·6 | 47·0 | ENE |
| 25 | 29·889 | 29 981 | 30·083 | 30 168 | 56·3 | 50·7 | NE | 25 | 30·149 | 30·229 | 30·252 | 30·293 | 50·0 | 44·9 | E |
| 26 | 30·174 | 30·205 | 30·209 | 30·233 | 59·7 | 48·8 | E | 26 | 30·295 | 30·303 | 30·251 | 30·262 | 52·2 | 46·2 | ESE |
| 27 | 30·197 | 30·185 | 30·121 | 30·127 | 62·3 | 46·9 | E | 27 | 30·216 | 30·190 | 30·099 | 30·090 | 55·2 | 46·6 | ENE |
| 28 | 30·076 | 30·041 | 29·937 | 29·888 | 62·6 | 49·2 | E | 28 | 30·007 | 29·957 | 29·842 | 29·771 | 51·1 | 47·4 | ESE |
| 29 | 29·789 | 29·757 | 29·615 | 29·527 | 65·2 | 55·9 | W | 29 | 29·670 | 29·634 | 29·595 | 29·672 | 56·8 | 41·5 | NNW |
| 30 | 29·557 | 29·710 | 29·770 | 29·806 | 55·3 | 39·2 | NW | 30 | 29·732 | 29·786 | 29·753 | 29·749 | 47·0 | 36·6 | N |

* Record lost.

### OCTOBER, 1888.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29·729 | 29·638 | 29·543 | 29·472 | 52·1 | 35·4 | NW | 1 | 29·638 | 29·597 | 29·518 | 29·460 | 46·0 | 34·6 | NNE |
| 2 | 29·368 | 29·289 | 29·252 | 29·284 | 43·2 | 35·0 | N | 2 | 29·303 | 29·165 | 29·068 | 29·205 | 49·1 | 36·6 | WNW |
| 3 | 29·297 | 29·365 | 29·439 | 29·541 | 51·3 | 28·1 | WNW | 3 | 29·337 | 29·454 | 29·503 | 29 531 | 51·6 | 38·1 | NNE |
| 4 | 29·586 | 29·613 | 29·515 | 29·573 | 51·3 | 34·1 | SW | 4 | 29·421 | 29·291 | 29·463 | 29·445 | 46·2 | 32·7 | NNW |
| 5 | 29·662 | 29·691 | 29·673 | 29·726 | 50·3 | 31·1 | WNW | 5 | 29·365 | 29·465 | 29·517 | 29·656 | 48·0 | 35·5 | WNW |
| 6 | 29·756 | 29·823 | 29·893 | 30·015 | 48·9 | 30·9 | N | 6 | 29·752 | 29·894 | 29·979 | 30·044 | 45·1 | 34·6 | NNW |
| 7 | 30·075 | 30·107 | 30·095 | 30·172 | 48·9 | 32·1 | NW | 7 | 30·029 | 30·081 | 30·058 | 30·117 | 51·2 | 36·0 | WSW |
| 8 | 30·176 | 30·195 | 30·135 | 30·135 | 50·3 | 29·0 | N | 8 | 30·099 | 30·136 | 30·090 | 30·094 | 55·1 | 42·1 | WNW |
| 9 | 30·097 | 30·095 | 30·048 | 30·059 | 52·9 | 32·1 | N | 9 | 30·064 | 30·084 | 30·055 | 30·070 | 54·3 | 47·0 | NW |
| 10 | 30·023 | 30·050 | 30·032 | 30·085 | 57·7 | 37·7 | W | 10 | 30·033 | 30·038 | 29·997 | 30·043 | 55·5 | 44·6 | WNW |
| 11 | 30·076 | 30·107 | 30·080 | 30·096 | 55·3 | 31·4 | W | 11 | 30·010 | 30·014 | 29·925 | 29·857 | 50·7 | 41·0 | WSW |
| 12 | 30·058 | 30·016 | 29·931 | 29·881 | 57·3 | 41·4 | WSW | 12 | 29·748 | 29·724 | 29·673 | 29·733 | 56·0 | 44·2 | W |
| 13 | 29·791 | 29·845 | 29·923 | 29·998 | 52·9 | 35·9 | N | 13 | 29·772 | 29·906 | 29·964 | 30·054 | 49·2 | 36·4 | N |
| 14 | 30·054 | 30·131 | 30·164 | 30·263 | 48·8 | 32·4 | N | 14 | 30·081 | 30·117 | 30·076 | 30·099 | 50·0 | 34·4 | WNW |
| 15 | 30·281 | 30·334 | 30·317 | 30·363 | 51·9 | 30·8 | W | 15 | 30·118 | 30·182 | 30·194 | 30·239 | 54·2 | 48·6 | W |
| 16 | 30·364 | 30·367 | 30·307 | 30·308 | 54·3 | 32·0 | WNW | 16 | 30·222 | 30·239 | 30·208 | 30·235 | 53·0 | 43·8 | WSW |
| 17 | 30·277 | 30·292 | 30·240 | 30·266 | 54·4 | 36·1 | N | 17 | 30·211 | 30·220 | 30·188 | 30·182 | 51·3 | 42·7 | W |
| 18 | 30·243 | 30·243 | 30·186 | 30·218 | 54·9 | 40·2 | ENE | 18 | 30·121 | 30·127 | 30·081 | 30·093 | 52·2 | 42·6 | NNE |
| 19 | 30·212 | 30·248 | 30·225 | 30·275 | 54·2 | 40·2 | E | 19 | 30·091 | 30·143 | 30·143 | 30·195 | 53·9 | 44·9 | SSW |
| 20 | 30·285 | 30·336 | 30·326 | 30·383 | 53·2 | 32·8 | E | 20 | 30·244 | 30·307 | 30·307 | 30·387 | 55·5 | 44·3 | ENE |
| 21 | 30·367 | 30·403 | 30·377 | 30·408 | 53·2 | 31·3 | ENE | 21 | 30·390 | 30·430 | 30·422 | 30·439 | 52·6 | 46·1 | ENE |
| 22 | 30·405 | 30·430 | 30·375 | 30·376 | 51·3 | 31·9 | E | 22 | 30·395 | 30·387 | 30·271 | 30·237 | 49·1 | 41·2 | ENE |
| 23 | 30·323 | 30·302 | 30·201 | 30·185 | 48·4 | 30·2 | W | 23 | 30·153 | 30·132 | 30·056 | 30·021 | 54·5 | 44·4 | W |
| 24 | 30·135 | 30·120 | 30·037 | 30·022 | 49·2 | 33·4 | SW | 24 | 29·935 | 29·890 | 29·812 | 29·755 | 51·8 | 44·8 | WSW |
| 25 | 29·968 | 29·969 | 29·948 | 29·958 | 60·9 | 43·3 | S | 25 | 29·673 | 29·620 | 29·558 | 29·558 | 56·5 | 51·4 | SW |
| 26 | 29·973 | 30·053 | 30·102 | 30·163 | 61·6 | 55·0 | SW | 26 | 29·518 | 29·622 | 29·693 | 29·669 | 60·5 | 54·8 | WSW |
| 27 | 30·177 | 30·234 | 30·237 | 30·256 | 66·9 | 56·9 | SW | 27 | 29·692 | 29·735 | 29·715 | 29·742 | 61·0 | 57·3 | SW |
| 28 | 30·226 | 30·203 | 30·131 | 30·128 | 63·6 | 55 9 | SSW | 28 | 29·694 | 29·643 | 29·571 | 29·685 | 59·2 | 49·8 | SW |
| 29 | 30·175 | 30·207 | 30·154 | 30·117 | 57·3 | 48·8 | SW | 29 | 29·804 | 29·875 | 29·855 | 29·897 | 51·1 | 45·7 | WSW |
| 30 | 30·066 | 29·923 | 29·851 | 29·928 | 51·8 | 47·3 | NE | 30 | 29·832 | 29·718 | 29·558 | 29·558 | 53·1 | 44·6 | SSW |
| 31 | 29·964 | 29·953 | 29·856 | 29·794 | 54·2 | 44·1 | SW | 31 | 29·493 | 29·476 | 29·541 | 29·555 | 51·5 | 42·4 | WSW |

## BAROMETER READINGS, &c.

### NOVEMBER, 1888.

| KEW. | | | | | | | | GLASGOW. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer. | | | | Temperature. | | | | Barometer. | | | | Temperature. | | |
| Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M. | Max | Min. | Direction of wind at noon | Date. | 4 A.M. | 10 A.M. | 4 P.M. | 10 P.M | Max | Min. | Direction of wind at noon |
| 1 | 29·686 | 29·596 | 29·540 | 29·508 | 49·3 | 40·7 | SSW | 1 | 29·564 | 29·651 | 29·716 | 29·801 | 47·9 | 34·9 | ENE |
| 2 | 29·395 | 29·389 | 29·432 | 29·460 | 49·1 | 45·9 | ESE | 2 | 29·826 | 29·831 | 29·785 | 29·767 | 47·3 | 40·6 | E |
| 3 | 29·502 | 29·559 | 29·625 | 29·711 | 50·8 | 42·2 | S | 3 | 29·790 | 29·837 | 29·829 | 29·866 | 46·8 | 43·5 | E |
| 4 | 29·736 | 29·753 | 29·710 | 29·656 | 54·9 | 42·9 | ESE | 4 | 29·848 | 29·844 | 29·803 | 29·813 | 45·9 | 43·4 | ESE |
| 5 | 29·709 | 29·801 | 29·811 | 29·835 | 54·5 | 43·7 | E | 5 | 29·821 | 29·909 | 29·938 | 30·018 | 45·5 | 43·5 | E |
| 6 | 29·816 | 29·839 | 29·769 | 29·763 | 45·8 | 37·9 | NE | 6 | 30·027 | 30·049 | 29·992 | 29·989 | 44·2 | 38·9 | ESE |
| 7 | 29·721 | 29·750 | 29·752 | 29·792 | 38·7 | 35·2 | E | 7 | 29·949 | 29·940 | 29·882 | 29·856 | 43·7 | 40·9 | ESE |
| 8 | 29·807 | 29·853 | 29·801 | 29·758 | 43·3 | 35·0 | E | 8 | 29·833 | 29·878 | 29·875 | 29·868 | 43·6 | 38·8 | ESE |
| 9 | 29·731 | 29·739 | 29·750 | 29·812 | 45·0 | 38·3 | E | 9 | 29·833 | 29·844 | 29·824 | 29·832 | 45·1 | 39·8 | ESE |
| 10 | 29·841 | 29·855 | 29·787 | 29·743 | 47·9 | 38·2 | ESE | 10 | 29·778 | 29·717 | 29·598 | 29·549 | 45·5 | 39·6 | SE |
| 11 | 29·756 | 29·822 | 29·829 | 29·824 | 50·8 | 43·1 | SE | 11 | 29·570 | 29·691 | 29·734 | 29·774 | 51·3 | 39·9 | SSW |
| 12 | 29·769 | 29·687 | 29·519 | 29·454 | 53·1 | 45·9 | E | 12 | 29·730 | 29·655 | 29·546 | 29·416 | 47·3 | 38·7 | ESE |
| 13 | 29·392 | 29·326 | 29·556 | 29·687 | 53·8 | 45·1 | SW | 13 | 29·348 | 29·412 | 29·388 | 29·388 | 47·8 | 45·0 | E |
| 14 | 29·781 | 29·906 | 29·987 | 30·095 | 56·0 | 42·0 | SW | 14 | 29·417 | 29·540 | 29·611 | 29·794 | 51·6 | 43·5 | SW |
| 15 | 30·109 | 30·107 | 30·107 | 30·153 | 56·2 | 49·9 | SSW | 15 | 29·762 | 29·492 | 29·806 | 29·837 | 52·9 | 43·8 | WSW |
| 16 | 30·093 | 30·048 | 30·064 | 30·135 | 58·7 | 48·9 | SW | 16 | 29·381 | 29·134 | 29·571 | 29·566 | 55·6 | 44·8 | WSW |
| 17 | 30·092 | 30·031 | 29·962 | 29·995 | 53·6 | 46·8 | W | 17 | 29·494 | 29·456 | 29·551 | 29·694 | 46·0 | 38·5 | W |
| 18 | 30·023 | 30·024 | 29·971 | 29·958 | 53·1 | 45·3 | SW | 18 | 29·760 | 29·714 | 29·641 | 29·640 | 50·4 | 40·0 | WSW |
| 19 | 29·923 | 29·926 | 29·840 | 29·763 | 54·5 | 51·1 | SW | 19 | 29·553 | 29·480 | 29·315 | 29·395 | 52·2 | 40·3 | WSW |
| 20 | 29·652 | 29·775 | 29·806 | 29·946 | 53·8 | 40·6 | W | 20 | 29·383 | 29·293 | 29·357 | 29·569 | 41·0 | 37·0 | WNW |
| 21 | 30·026 | 30·106 | 30·086 | 30·179 | 49·1 | 40·1 | W | 21 | 29·729 | 29·724 | 29·875 | 29·819 | 44·8 | 36·5 | WNW |
| 22 | 30·169 | 30·151 | 30·136 | 30·166 | 53·3 | 45·1 | W | 22 | 29·671 | 29·628 | 29·592 | 29·643 | 52·0 | 45·2 | WSW |
| 23 | 30·165 | 30·197 | 30·223 | 30·215 | 55·1 | 50·3 | WSW | 23 | 29·709 | 29·791 | 29·821 | 29·667 | 49·6 | 44·1 | W |
| 24 | 30·128 | 30·083 | 30·071 | 30·063 | 54·8 | 49·8 | WSW | 24 | 29·398 | 29·563 | 29·552 | 29·548 | 53·3 | 46·1 | W |
| 25 | 29·984 | 29·929 | 29·803 | 29·613 | 55·2 | 52·2 | SW | 25 | 29·482 | 29·226 | 29·202 | 29·160 | 52·1 | 40·4 | WSW |
| 26 | 29·539 | 29·595 | 29·642 | 29·653 | 53·0 | 45·9 | W | 26 | 29·171 | 29·224 | 29·341 | 29·403 | 41·2 | 35·1 | WSW |
| 27 | 29·540 | 29·291 | 29·230 | 29·356 | 53·0 | 42·0 | SSW | 27 | 29·357 | 29·220 | 28·979 | 29·116 | 39·5 | 33·3 | E |
| 28 | 29·386 | 29·457 | 29·430 | 29·431 | 44·5 | 34·9 | SW | 28 | 29·281 | 29·413 | 29·476 | 29·516 | 39·2 | 34·0 | N |
| 29 | 29·330 | 29·318 | 29·237 | 29·209 | 47·2 | 41·9 | E | 29 | 29·470 | 29·444 | 29·338 | 29·321 | 42·0 | 34·5 | ENE |
| 30 | 29·172 | 29·240 | 29·364 | 29·511 | 47·2 | 38·9 | NE | 30 | 29·303 | 29·350 | 29·392 | 29·480 | 42·3 | 36·2 | ENE |

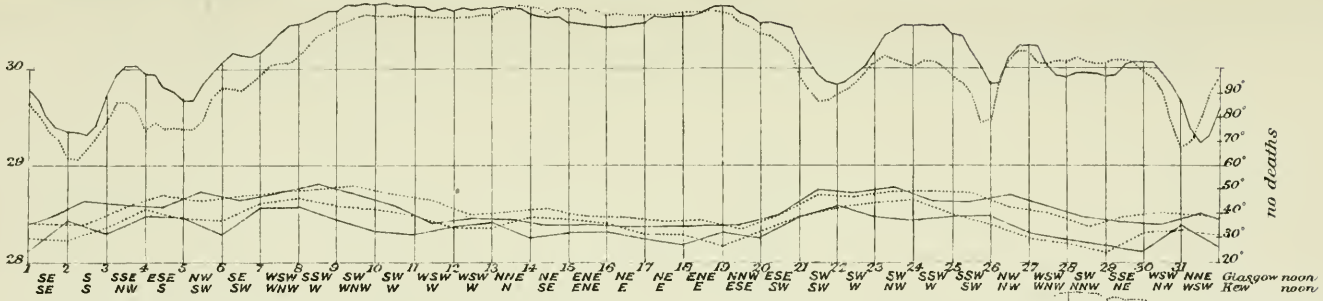
### DECEMBER, 1888.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29·599 | 29·746 | 29·835 | 29·909 | 47·6 | 37·1 | WSW | 1 | 29·512 | 29·536 | 29·466 | 29·470 | 47·3 | 37·0 | SSE |
| 2 | 29·950 | 30·031 | 30·027 | 30·034 | 52·0 | 44·1 | SW | 2 | 29·574 | 29·611 | 29·542 | 29·592 | 50·0 | 43·2 | SSW |
| 3 | 30·005 | 29·979 | 29·901 | 29·902 | 51·7 | 49·0 | S | 3 | 29·512 | 29·329 | 29·269 | 29·416 | 54·4 | 48·8 | SSW |
| 4 | 29·930 | 30·039 | 30·086 | 30·137 | 55·7 | 49·1 | SSW | 4 | 29·509 | 29·712 | 29·846 | 29·883 | 52·5 | 47·8 | WSW |
| 5 | 30·133 | 30·158 | 30·155 | 30·181 | 57·3 | 50·2 | SSW | 5 | 29·804 | 29·772 | 29·776 | 29·853 | 53·5 | 49·0 | SSW |
| 6 | 30·170 | 30·228 | 30·159 | 30·124 | 54·9 | 42·9 | S | 6 | 29·902 | 29·992 | 29·964 | 29·856 | 52·2 | 49·6 | SSE |
| 7 | 30·038 | 30·014 | 30·002 | 30·050 | 51·3 | 36·0 | S | 7 | 29·715 | 29·674 | 29·690 | 29·816 | 52·7 | 45·7 | S |
| 8 | 30·061 | 30·078 | 30·039 | 30·061 | 49·1 | 32·2 | SW | 8 | 29·939 | 30·021 | 30·007 | 30·012 | 45·8 | 40·2 | SW |
| 9 | 30·140 | 30·249 | 30·261 | 30·305 | 45·8 | 30·3 | W | 9 | 30·057 | 30·171 | 30·199 | 30·234 | 44·3 | 37·8 | WNW |
| 10 | 30·304 | 30·343 | 30·318 | 30·320 | 32·0 | 27·1 | NNW | 10 | 30·262 | 30·278 | 30·262 | 30·225 | 39·2 | 29·6 | ENE |
| 11 | 30·313 | 30·299 | 30·242 | 30·252 | 39·0 | 28·0 | NNW | 11 | 30·162 | 30·105 | 30·026 | 30·053 | 38·0 | 32·0 | ENE |
| 12 | 30·266 | 30·341 | 30·342 | 30·378 | 39·0 | 30·8 | ESE | 12 | 30·092 | 30·142 | 30·129 | 30·146 | 43·0 | 36·3 | SSE |
| 13 | 30·339 | 30·339 | 30·255 | 30·240 | 35·8 | 27·4 | ESE | 13 | 30·117 | 30·117 | 30·057 | 30·045 | 42·0 | 39·0 | SE |
| 14 | 30·221 | 30·257 | 30·245 | 30·313 | 38·4 | 27·9 | E | 14 | 30·023 | 30·063 | 30·101 | 30·225 | 44·8 | 35·8 | SSW |
| 15 | 30·338 | 30·392 | 30·393 | 30·427 | 38·0 | 30·0 | NNE | 15 | 30·304 | 30·368 | 30·342 | 30·353 | 42·5 | 31·4 | WSW |
| 16 | 30·443 | 30·483 | 30·431 | 30·432 | 39·1 | 34·3 | WNW | 16 | 30·347 | 30·319 | 30·252 | 30·215 | 44·2 | 42·0 | WSW |
| 17 | 30·390 | 30·375 | 30·329 | 30·313 | 35·6 | 29·2 | WSW | 17 | 30·195 | 30·191 | 30·147 | 30·153 | 43·2 | 39·8 | WSW |
| 18 | 30·248 | 30·183 | 30·067 | 30·021 | 32·9 | 28·0 | W | 18 | 30·085 | 30·018 | 29·876 | 29·768 | 42·8 | 34·9 | SW |
| 19 | 29·961 | 29·942 | 29·835 | 29·767 | 46·7 | 32·9 | S | 19 | 29·631 | 29·527 | 29·378 | 29·312 | 51·0 | 37·9 | SSW |
| 20 | 29·669 | 29·629 | 29·556 | 29·501 | 47·5 | 40·0 | S | 20 | 29·393 | 29·404 | 29·290 | 29·263 | 47·0 | 40·2 | ENE |
| 21 | 29·361 | 29·256 | 29·061 | 28·964 | 50·3 | 45·3 | SSE | 21 | 29·153 | 29·013 | 28·885 | 28·869 | 48·6 | 37·2 | SE |
| 22 | 28·954 | 29·114 | 29·285 | 29·395 | 50·9 | 43·9 | S | 22 | 28·874 | 28·999 | 29·155 | 29·300 | 48·2 | 45·3 | ENE |
| 23 | 29·441 | 29·516 | 29·544 | 29·586 | 48·2 | 41·2 | SSE | 23 | 29·403 | 29·460 | 29·395 | 29·251 | 45·9 | 43·2 | ESE |
| 24 | 29·573 | 29·487 | 29·452 | 29·530 | 50·0 | 42·0 | SSW | 24 | 29·105 | 29·101 | 29·242 | 29·407 | 45·1 | 35·5 | WSW |
| 25 | 29·712 | 29·711 | 29·441 | 29·529 | 49·0 | 32·6 | SSE | 25 | 29·484 | 29·386 | 29·060 | 29·132 | 41·1 | 34·3 | SE |
| 26 | 29·645 | 29·765 | 29·847 | 29·960 | 45·1 | 33·1 | SW | 26 | 29·308 | 29·484 | 29·599 | 29·659 | 39·8 | 33·4 | SW |
| 27 | 29·977 | 29·901 | 29·711 | 29·626 | 50·0 | 32·3 | S | 27 | 29·672 | 29·515 | 29·233 | 29·224 | 40·4 | 34·0 | ESE |
| 28 | 29·502 | 29·464 | 29·554 | 29·668 | 48·8 | 34·6 | W | 28 | 29·168 | 29·256 | 29·448 | 29·668 | 42·0 | 32·3 | WNW |
| 29 | 29·732 | 29·844 | 29·885 | 29·959 | 39·9 | 34·9 | N | 29 | 29·777 | 29·939 | 30·020 | 30·092 | 38·0 | 28·7 | NW |
| 30 | 29·973 | 30·058 | 30·078 | 30 136 | 39·9 | 31·8 | N | 30 | 30·123 | 30·140 | 30·077 | 30·018 | 34·0 | 24·3 | NW |
| 31 | 30·134 | 30·137 | 30·069 | 30·099 | 32·2 | 26·1 | N | 31 | 29·948 | 29·866 | 29·744 | 29·819 | 42·5 | 33·8 | S |

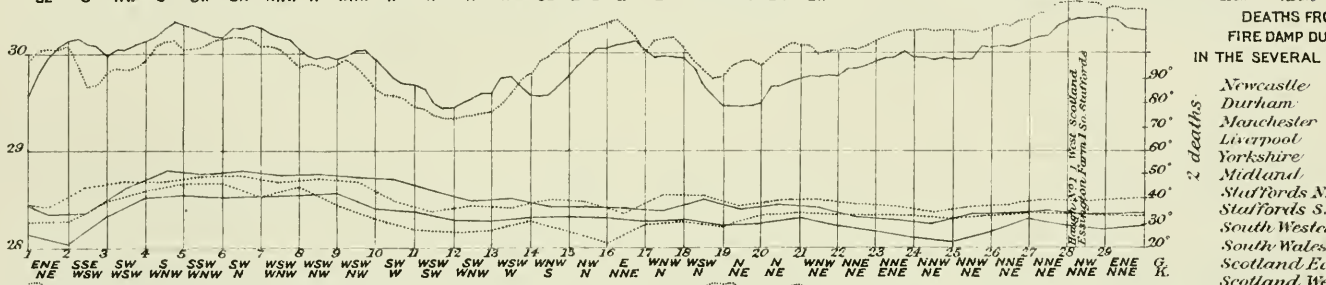
# DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1888

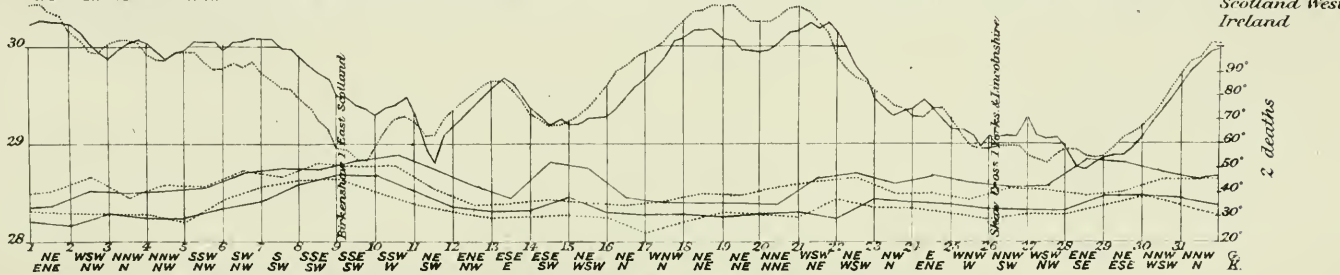
JANUARY.




FEBRUARY.




MARCH.




## DEATHS FROM EXPLOSIONS OF FIRE DAMP DURING THE YEAR 1888 IN THE SEVERAL INSPECTION DISTRICTS.

| | |
|---|---|
| Newcastle | 31 Deaths |
| Durham | 0 " |
| Manchester | 0 " |
| Liverpool | 3 " |
| Yorkshire | 4 " |
| Midland | 0 " |
| Staffords N. | 0 " |
| Staffords S. | 2 " |
| South Western | 0 " |
| South Wales | 8 " |
| Scotland East | 2 " |
| Scotland West | 1 " |
| Ireland | 0 " |
| | 51 |

*The firm top line is the Barometer reading at Kew taken at 4 a.m. 10 a.m. 4 p.m & 10 p.m*
*The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.*
*The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m & 10 p.m.*
*Kew lines are firm Glasgow lines are dotted*
*The figures attached to the districts shew the Number of deaths caused by the explosions.*

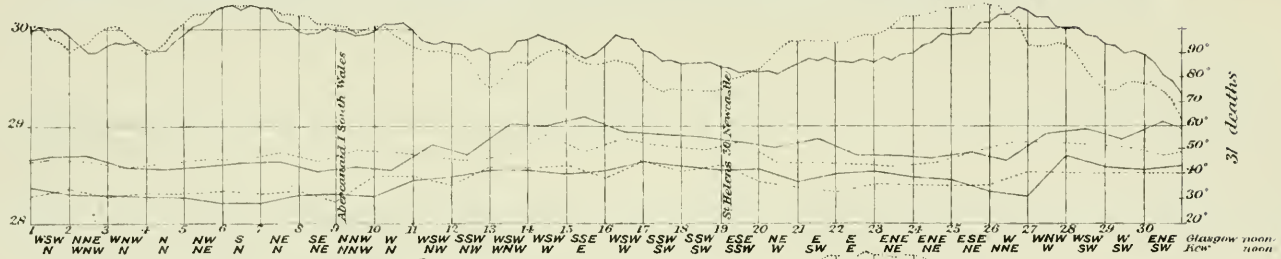


And.w Reid, Sons & C.o Lithos Newcastle

# DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1888

APRIL.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St Helens 36 Newcastle
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Glasgow noon
Kew noon

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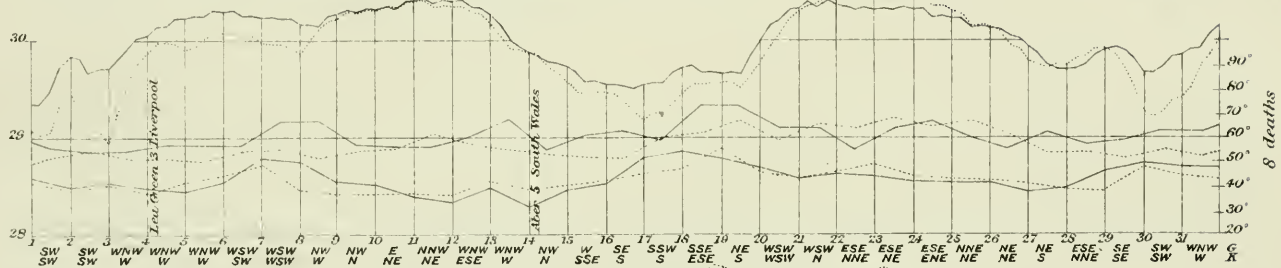
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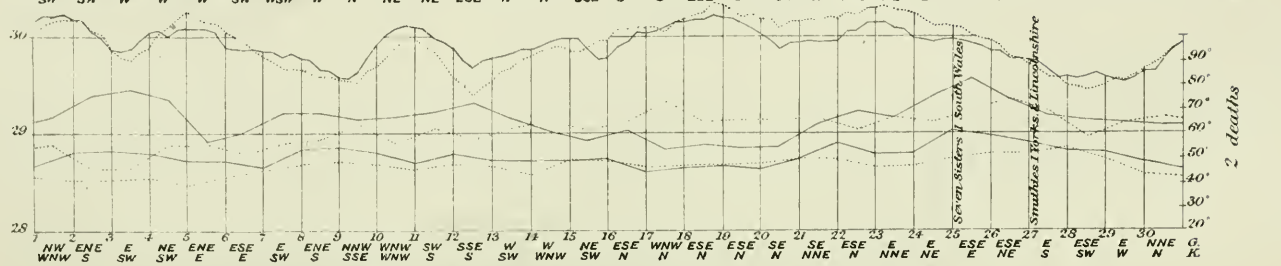
JUNE.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*The firm top line is the Barometer reading at Kew taken at 4a.m. 10a.m. 4p.m. & 10p.m.*
*The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.*
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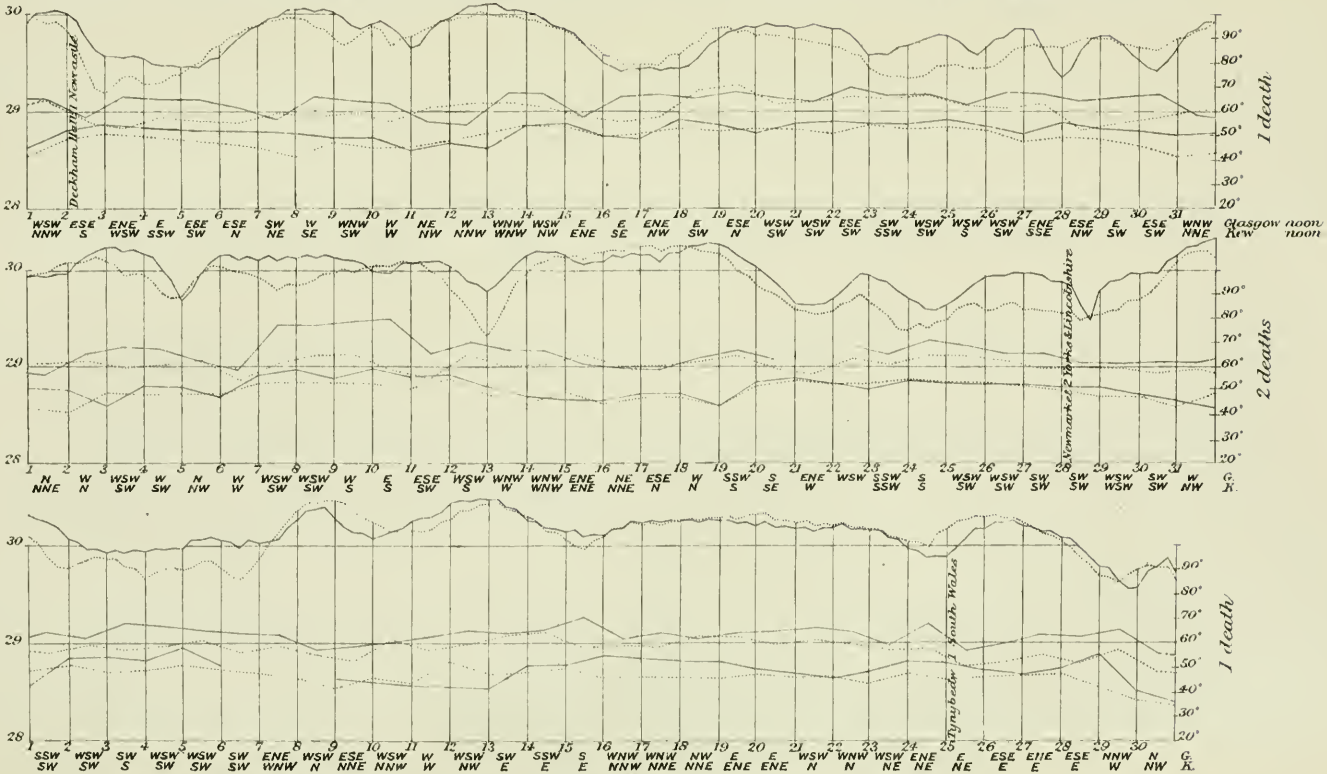


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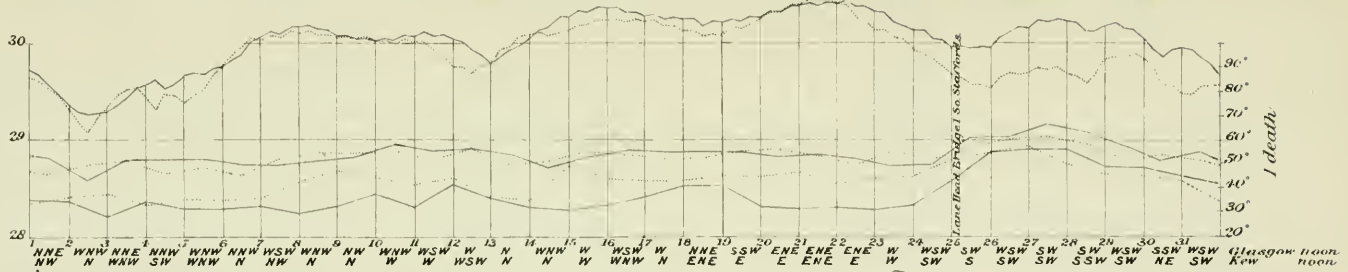
1888

OCTOBER.

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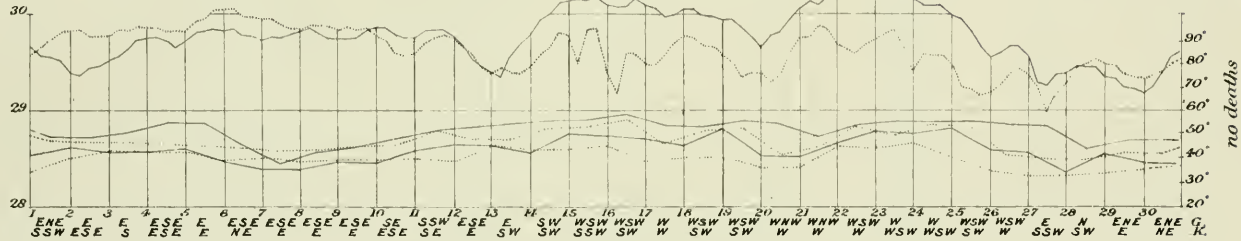
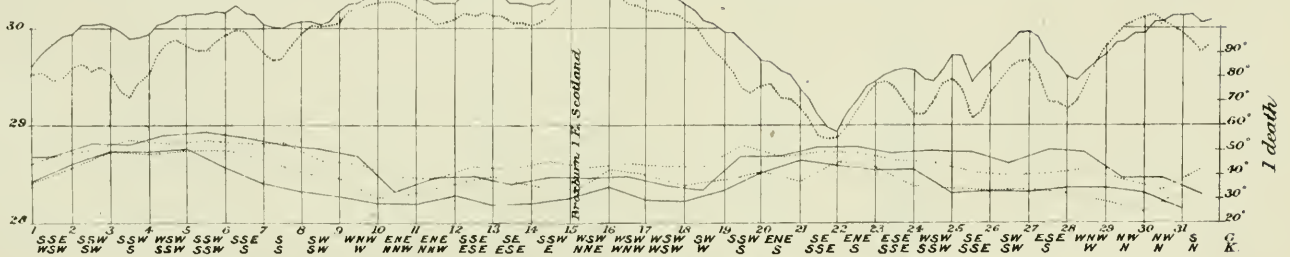



DECEMBER.

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NORTH OF ENGLAND INSTITUTE

OF

# MINING & MECHANICAL ENGINEERS.

## ABSTRACTS OF FOREIGN PAPERS.

### THE BORING AT SCHLADEBACH.

*Ueber die Temperatur-Beobachtungen im Bohrloche zu Schladebach.* By E. Dunker, *Neues Jahrbuch, Jahrgang, 1889, I. Band, I. Heft, pp. 29-47. Stuttgart, 1889.*

The boring at Schladebach, near Dürrenberg, was commenced in the year 1884, and has now reached a depth of 1,748 metres (5,750 feet). It passes right through the Bunter Sandstone, Zechstein (Magnesian Limestone), Rothliegendes (Permian Sands), and Coal Measures, down to the Upper Devonian.

After giving a table of the diameters of the borehole, varying from 120 mm. (4·72 ins.) at the surface, to 4·8 mm. (1·88 ins.) at the depth of 1,376 metres (4,515 feet), the author furnishes a brief description of an apparatus which he devised for shutting off, by means of plastic clay, short columns of water, with a view to thermometric observations. He intends to publish later on a full description, which will be elucidated by drawings.

Three tables of temperature observations, pp. 32, 35, and 36, fail to show a regular rate of increase of temperature; but it may be gathered from the context that these irregularities are partly attributable to disturbing causes such as the varying texture of the rocks, slight convection currents in the water, friction, and so on. One series of observations was made in a "slurry" of clay, instead of water, and though the total increase of temperature was found to be the same in both fluids, the *actual* temperature of the water was invariably higher than that of the clay slurry.

With regard to the rate of increase of underground temperature, the author enters into elaborate calculations, based upon the above-mentioned results, and he finds that for every 35·7 metres (117 feet) the temperature increases 1 deg. C. At Sperenberg, the same increase was found to take place for every 33·7 metres (110 feet). The author, in conclusion, makes various practical suggestions as to the precautions which it would be advisable to take in future, in connection with similar observations.

L. L. B.

## THE TRANSVAAL GOLD DISTRICTS.

*Les gisements métallifères du Transvaal, and Goldführende Conglomerate in Südafrika. Abstracts (1) by* E. Cohen, *and (2) by* A. W. Stelzner, *Neues Jahrbuch, Jahrgang, 1889, I. Band, I. Heft, Referate, pp. 112-113. Stuttgart, 1889.*

The above are fairly detailed descriptions of the situation and nature of the rocks which constitute the matrix of the gold in the Witwatersrand and the Barberton districts. L. L. B.

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## THE KUSSINSK MINE IN THE URALS.

*Die Nicolai-Maximilianowsk Grube beim Hüttenwerk Kussinsk am Ural, and Brucit aus der N.-M. Grube am Ural. Abstracts by* Th. Tschernyschew, *Neues Jahrbuch, I Band, I Heft, Referate, pp. 10-12, and 13. Stuttgart, 1889.*

The minerals found in this mine include massive Epidote, Garnet, Magnetite, Ilmenite, Brucite, &c., and Spinel occurs abundantly,—a mass of this mineral weighing 25½ pounds having been found by the author of the first-mentioned paper. Careful analyses of the Brucite show that it contains 69 per cent. of magnesia, and its specific gravity is 2·4.—The above minerals occur in three large veins in limestone. A sketch showing the position of the workings accompanies the text: they are in a line running approximately S.W. and N.E. L. L. B.

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## NATURAL FERRIC SULPHATES IN CHILE.

*Hohmannit and Amarantit, and Paposit, ein neues Eisensulphat. Abstracts by* Max Bauer, *Neues Jahrbuch, Jahrgang 1889, I Band, I Heft, Referate, pp. 23-25. Stuttgart, 1889.*

The Minerals Hohmannite and Amarantite were both found by A. Frenzel, the author of the first-mentioned paper, at Caracoles near the banks of the River Loa. Paposite was found at *la Union* Mine (Reventon) near Paposa in the province of Atacama. The first two minerals contain from 36 to 40 per cent. ferric oxide, and the last-named mineral contains 30 per cent. The percentage of sulphur trioxide ranges from 25 to 36 per cent. L. L. B.

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## THE ISLAND OF CORFU.

*Die Insel Korfu. Abstract by Herr* Penck, *Neues Jahrbuch, Jahrgang 1889, I Band, I Heft, Referate, pp. 103-106. Stuttgart, 1889.*

The oldest strata known in the island are, doubtfully of the Trias, and certainly of the Lias. The Hippurite Limestones are saccharoidal; lignites occur in the Flysch formation, and enormous masses of gypsum in the Pliocene. Slight earthquakes are of frequent occurrence. A new topographical map, and a geological map accompany the original work. L. L. B.

## THE NORTHERLY PORTION OF THE WESTPHALIAN COALFIELD.

*Die Ablagerung der Productiven Steinkohlen Formation in der Horst-Recklinghausener Mulde des Niederrheinisch-Westfälischen Steinkohlenbeckens.* By E. HILGER. *Zeitschrift für das Berg-, Hütten-, u. Salinen-Wesen im Preussischen Staate. XXXV. Band, I. Heft, pp. 30-54. Sections in the Text and Plate VII. Berlin, 1887.*

The Coal Measures of the Horst-Recklinghausen basin are overlaid by Cretaceous rocks, and their geological aspect does not differ materially from that of the other portions of the Westphalian coalfield; sandstones, clay slates, and coal seams succeed each other in the usual order. No great unconformities are known to exist except at one pit, where at many points the Lower Greensand marl has been met with about 300 feet below its usual horizon. The author enters at some length into the description of the seams, and describes four great faults by which they are disturbed. It is noticeable that these disturbances, traced downwards into the older carboniferous and the Devonian strata where they often become metalliferous lodes, do not extend upwards into the chalk formation.

Generally speaking, the long flame coal (Gas flammkohle) attains an extraordinary development in this district, and that of the Graf Bismarck—Ewald workings is the finest in the Westphalian Coalfield; it is extremely hard, shiny, sonorous, and breaks into rhombohedral fragments.

Correlation of the Westphalian coal seams by means of the fossils found in the super or sub-incumbent rocks is impossible, but according to the predominance of certain orders of plants, the Coal Measures have been divided roughly into three zones: the Lower or *Lepidodendron* Zone, the Middle or *Sigillaria* Zone, and the Upper or *Calamites* Zone. Thanks to the information obtained by the sinking of new shafts very recently, a practically complete section of the Westphalian Coal bearing rocks has been drawn up: of these the author subjoins a table, in addition to the plate in the Atlas. The entire thickness of the Coal Measures there is 9,200 feet, of which 310 feet or about $\frac{1}{30}$ may be reckoned as good coal.

L. L. B.

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## THE SINKING OF SHAFTS IN WATER-BEARING STRATA.

*Neuerungen und Fortschritte beim Abteufen von Schächten in Schwimmsand und wasserreichem Gebirge.* By H. LUEG. *Zeitschrift für das Berg-, Hütten-, u. Salinen-Wesen im Preussischen Staate. XXXV. Band I. Heft, pp. 1-29. Sections in the text and Plates I. to VI. Berlin, 1887.*

In this paper, read at the third general meeting of German Mining Engineers at Düsseldorf, the author gives a short description of the patents taken out since 1883 for sinking shafts through wet sand and water-bearing beds, following this up by a detailed account of some of the shafts thus sunk in Germany since the above-mentioned year.

He discusses also the merits of the various processes, and, for sinking through loosely coherent strata, recommends cast iron tubbing, whilst for sinking through firmer rocks, he gives the preference to the Kind-Chaudron process.

L. L. B.

## THE MANUFACTURE OF COKE IN WESTPHALIA.

*Die Koksfabrikation im Oberbergamtsbezirke Dortmund mit Berücksichtigung des fremden Wettbewerbs. By.* F. SIMMERSBACH. *Zeitschrift für das Berg-, Hütten-, u. Salinen-Wesen im Preussischen Staate, XXXV, Band IV Helf, pp. 277-331, map and sections in the text and Plate XVII. Berlin, 1887.*

This paper is replete with interesting statistics, and includes, besides a historical review of coke manufacture in England and Germany, a full account of the ovens and regenerators in use in the district under consideration and the method there adopted for washing the coal.

It appears that the production of coke in Germany was sextupled in the decade 1870-1880, and in 1886, in the official Mining Division of Dortmund there were 5,242 coke ovens at work, producing 2,557,013 tons. The mean wages of a coke burner at Dortmund, in June 1886, were 2 marks 72 pfennige, say 2s. 9d. per day, and the average cost of production of Westphalian Coke was, at the same date, 7·08 marks, say 7s. 1d. per ton.

The good coking coals of the Westphalian Coalfield are contained in 23 workable seams, the amount of coke obtained averaging from 70 to 85 per cent. of the coal employed.

Comparative statistics are given of the imports of coke into various counties from England and Germany during 1885, and we learn that, in 1886, the total export of coke from Germany amounted to 640,656 tons. L. L. B.

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## BENZINE LAMPS IN COAL MINES.

*Percussions Zündung und Benzin Lampe. By* DR. SCHONDORFF. *Zeitschrift für das Berg-, Hütten-, u. Salinen-Wesen im Preussischen Staate, XXXV. Band, IV. Heft, pp. 331-335. Berlin, 1887.*

The author made experiments on explosions in the Laboratory of the Prussian Fire-Damp Commission, and he found that the risk of inflammation by percussion was considerable in the case of benzine lamps. This risk increases in practice, because the meshes of the protecting gauze become partly stopped up by dirt and dust, and the effective surface is thus diminished : a diminution of $\frac{1}{7}$ was followed by evil results in his experiments. By electric inflammation in mixtures containing marsh gas, none of the safety lamps hitherto in use (with the exception of a few wide meshed Siebring lamps) exploded.

It is not perhaps universally known that very small quantities of benzine vapour are requisite to form an extremely explosive mixture—2·16 per cent. produces a mixture equal in explosive power to fire-damp containing 9·5 per cent. marsh gas.

After mentioning a case of inflammation by percussion which occurred in a pit in the Saarbrücken District, in April, 1887, with a Wolf's benzine lamp, the author concludes against the use of benzine in mines, and points out that, if due encouragement were given, makers could provide ordinary oil lamps of at least equal lighting power. L. L. B.

## WASTE IN MINING IN PENNSYLVANIA.

*By* P. W. Sheafer. *The Engineering and Mining Journal (New York,) 1888, Vol. XLVI, pp. 367-8.*

### Duration of Coalfields.

Experience has shown that the waste in mining anthracite in the Southern, Middle and Northern Coalfields of Pennsylvania, is equal to two-thirds of the coal deposit. The available supply of coal is estimated on January 1, 1888, at 24,321,376,611 tons, and the amount available for market would be 8,107,125,537 tons. At the present rate of production (40 million tons) the coalfields will be exhausted in 202 years, as at the rate of 50 million tons will be exhausted in 162 years.

### Waste in Mining.

In the smaller beds, of 8 to 10 feet in thickness, 50 per cent. of the coal has been mined, while in the Mammoth bed, the results show that only 20 to 25 per cent. of the available coal is brought to market.

The loss in breaking and preparing the coal for market is very great. In 13 experiments made in 1869 with good, hard, clean Lehigh coal (clean of dirt), there was 26 per cent. of waste; several of the experiments showed the waste to be 15·71 per cent. of the coal. Later experiments show but little improvement in the breaking of the coal. Mr. Platt in his book on "Coal Waste," gives 15½ per cent. for loss in breaking, and 18 to 30 per cent. for loss in mining, blasting, and re-handling. The greatest loss is, however, in the quantity unmined and left in the ground for support.

This is the place to look for improvement. The thinner beds be worked by the methods now in use; but economy can be practised in the thicker beds.

### Improved Mining of the Mammoth Coal.

The lifts should not exceed 50 or 60 yards in length, breasts should be driven their full length, and the coal "cut out," not "run" by robbing the pillars. The gangways in each lift should be driven to the boundaries of the area leased, and then worked towards the outlets.

Whenever possible, the gangways should be driven in the thin underlying beds, and the Mammoth coal attacked through galleries driven through the dividing rock: the permanent work being made outside the thicker beds.

The Philadelphia and Reading Coal and Iron Company are securing more than half of their coal by uncovering the surface, where the cover does not exceed the thickness of the bed of coal.

A plan has been recently adopted at the Kohinoor Colliery, in the Shenandoah district, of Schuylkill County, by which about 75 per cent. of the coal is worked. At this point the Mammoth bed is lying horizontal, and about 40 feet thick. At least 50 per cent. would be required to support the surface and the town.

The plan being worked is to bore through the superincumbent strata 400 feet thick, 8-inch holes to the top of the coal bed. A "scraper line" of cast-iron trough 10 inches deep and 12 inches wide, with continuous bands of scrapers moving in them, connect the immense banks of culm at the breaker with the hole, some 1,600 feet apart. The scraper line delivers continuously a large amount of culm at the mouth of the hole, where it meets a stream of water, and a mixture of three parts of water and one part of culm constantly drops into the mine below, and there distributes itself, permeating every nook and corner of the cavities. It entirely fills the chamber, even to the roof, and supports the pillars, but leaves them accessible to the miner for removal, when the spaces surrounding them are entirely filled. The currents of water and culm are directed, limiting the culm

by dams or batteries, and allowing the water to flow to the main sump of the mine, whence it is pumped out, to be again used in carrying more culm to its original abiding place. Filling with culm alone does not answer the purpose, as it would form a cone of loose dirt and of no strength ; the deposit formed by the water and culm becomes a solid mass, so hard as to require a pick to remove it, and forming a sufficient support for the surface or strata above the seam. The material is cheap, abundant, and convenient. M. W. B.

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## NOTTINGHAM COLLIERY, PENNSYLVANIA.

*The Colliery Engineer (U.S.), 1889, Vol. IX., pp. 95-96. 3 figures.*

Six tubs are drawn at a time by a pair of direct-acting engines, 22 inches diameter and 4 feet stroke, with conical drums 7 and 10 feet diameter, and each 8 feet long.

*Pit Bank.*—There are two lines of rails at bank, running through the shaft to the two dumps, and two lines running past the shaft, from the tipplers to the "transfer truck."

A small hauling engine, with reversing near the shaft, is employed to move a hauling rope, which is carried about 5 feet above the level of the empty roads from the dumps to the transfer truck.

When a loaded cage comes to bank, the empty tub standing on the transfer truck is started, and running down grade, collides with the loaded tub in the cage and starts it on the road to the dump. The empty tub runs into the cage and is locked in. As soon as the full tub is tipped, it is attached to the hauling rope by a short chain, the engine is then started so as to draw the rope and tub up grade from the dump to the transfer truck. The transfer truck is then moved by gearing, actuated by a belt from the engine, until the tub stands square behind the compartment of the shaft from which it was raised. Spring points are provided near the dumps to direct the empty tubs into the empty road.

*Pit Bottom.*—The grades of the roads are so arranged that the loaded tubs from both sides of the shaft run by gravity to the shaft, bump out the empty tubs, which run by gravity to the empty sidings on the east and west sides of the shaft.

The time required to hoist a wagon and dump it (a height of 470 feet) is only 15 seconds. The record is 1,252 tubs in 9 hours. Each tub carries over 2 tons.

*Haulage.*—The shaft is 365 feet deep, to the Red Ash Vein 22 feet thick, and thence a drift 1,000 feet long, to the Ross Vein 7 feet thick. There is a haulage plane 2,500 feet long in the Red Ash Vein dipping 14 degs. The drift is laid with a single track. The hauling engines are situated on the surface, and the rope is carried down a bore hole to the workings on the east side of the haulage plane. The rope passes under a sheave at the bottom of the bore hole, and runs towards the slope, where it passes around a horizontal sheave, and thence down the slope.

*Ventilation.*—The workings are ventilated by two 24 feet Guibal fans, drawing 250,000 cubic feet per minute at the intake. Steam being supplied from cylindrical boilers three 30 feet long and four 48 feet long, and all 30 inch diameter.

M. W. B.

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## ELECTRIC COAL CUTTING MACHINES.

*Coal Mining Machines operated by Electricity. The Engineering and Mining Journal (New York), 1888, Vol. XLVI., p. 545.*

The machine has been designed by Mr. F. M. Lechner, and is in daily use at the Drane Colliery, near Osceola, Clearfield Co., Pennsylvania.

The motor, which is a 10 horse power of the Sprague type, is mounted upon a tram, running upon rails, so that it is easily handled and hauled to various positions as occasion requires. The weight of the motor is about 1,000 pounds.

The coal-cutter, which is of the New Lechner type, is set in position in the "room" and is connected to the motor by a $\frac{5}{8}$th inch endless rope running in V shaped grooved sheaves, one being as the motor and the other on the cutter. This connection is long enough to allow the motor to be worked 30 feet away from the cutter. The dynamo is a distance of 1,600 feet.

The cutter can be worked at any angle from the motor, by means of loose sheaves, attached to screw jacks, which can be easily adjusted at any height. The connection is made by moving the tram upon which the motor rests, and securing it in a proper position by guys.

By this plan, three coal-cutters can be operated by one motor, for when one "room" is cut the motor can at once be hauled to another "room" where a coal-cutter is in readiness and position, cut that "room" and pass to a third, while the coal is being removed from the first two, and the coal-cutters again placed in position.

Two men are able to kirve 100 yards in 10 hours, and can move the machine without auxiliary aid.

The efficiency of the dynamo and motor are each said to be 90 per cent., and allowing 10 per cent. loss in the cable, about 73 per cent. of the power applied to the dynamo may be developed in the motor. M. W. B.

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## SAND CARTRIDGES.

*Die Schlagwetter nicht zündende Sand-Patrone. By Herr* Bergrath Wilhelm Jicinski, *Glückauf. Vol. XXIV., pp. 650-1.*

The cartridges are composed of an ordinary dynamite cartridge, placed centrally in a paper case, filled with ordinary fine moist sand, and the open end closed tightly round the wires of the detonator. The sand should be saturated, but not dripping, with water. Kieselguhr, a diatomaceous earth, may be used instead of sand. The dynamite should be surrounded by $\frac{1}{2}$ inch of the sand, consequently with a $\frac{3}{4}$ inch cartridge, the paper case would be $1\frac{3}{4}$ inches diameter.

The outer case should be made of strong paper, rendered waterproof by oil—paraffin, or otherwise.

Experiments have been made with cartridges surrounded by $\frac{1}{4}$ and $\frac{1}{2}$ inch of sand, containing 7 ounces of dynamite, fired in explosives mixtures of air and fire-damp, and in the presence of coal dust without any ignition.

M. W. B.

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## MODEL HOISTING ARRANGEMENTS.

*The Colliery Engineer. Vol. IX., 1889, pages 119-121, and 4 figures.*

The arrangements at the top and bottom of the No. 2 shaft, of the standard mines of A. C. Frick Coke Company, Pennsylvania, were designed to handle 3,000 tons per day.

The shaft is 306 feet to the Connellsville coking coal; it is 10 feet by 24 feet inside, and fitted up for two cages, a pump way, and an air way.

The arrangements of the tracks and grades at the bottom of the shaft are in favour of the movement of both loaded and empty cars.

The winding machinery consists of a pair of direct acting engines, each 30 inches diameter, and 4 feet stroke. The drums are conical, 10 feet and 12½ feet in smallest and largest diameters, with 3 feet face.

The cars having a capacity of 2½ tons, machinery is employed to move them on the surface. The cars run down grade from the cage to the tipple, and then run from the tipple to a transfer truck on an incline behind the shaft. At this point the car is 12 inches below the level of the cage, which is overcome by the transfer truck being moved up an incline to a point opposite the cage, and on the same level. This is accomplished by means of a steam cylinder having a stroke equal to the travel of the truck, 10 feet 9 inches. There is the same arrangement for the other cage, but it may be noted that the steam cylinder moves both of the transfer trucks, one truck being opposite one cage, while the other is receiving the car from the tipple.

The steam ram is situated behind each empty car, where it is ready to be pushed into the cage, and the act of pushing on the empty car pushes the full one out, which runs on the down grade to the tipple already mentioned.

The coal is teamed from the pit cars into a hopper with a capacity of 450 tons, from which it is taken by tubs to the coke ovens.

All details are shown in the accompanying plans. M. W. B.

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## THE QUICKSILVER MINES OF NEW ALMADEN, CALIFORNIA.

*The Engineering and Mining Journal (New York), 1889, Vol., XLVII, page 10 and 11, and 2 views.*

The mine is situated about 13 miles from San Jose, California, at a height of 1,700 feet above the sea, in a low range of hills composed of serpentines overlain by black magnesian schists containing much iron and alumina, and which are in their turn overlain by metamorphosed jaspery clay slates. The deposit of cinnabar lies between the hanging wall of magnesian schists and the foot wall of serpentine. The vein appears to be a serpentine, somewhat altered by infiltrating water. It is sometimes hard and tough to mine, and at other times, soft and fragile. The cinnabar is associated with dolomitic crystals of pearlspar, iron pyrites, chlorite, rarely quartz, and a peculiar bituminous body resembling coal, which melts and flows like bitumen when heated. A sandstone overlies the vein matter in parts of the mine, and in places contains small quantities of native mercury.

The quicksilver has chiefly been found in a great chute, in which the ore occurs in vertical chimneys, in nearly horizontal beds, and on an endless variety of dips, and is of very various thicknesses. About 75,000,000 gallons of water are pumped per annum.

About 425 persons are employed in the extraction of 138,640 tons of ore, or say 326 tons per year of 290 days per worker. Wages per day are :—Miners, 11s. 3d.; labourers, underground and on surface, 8s.; firemen. 7s.; timbermen, 12s. 9d.; carpenters, 12s. 3d.; blasters, 11s.; quarrymen, 6s.

The cost per ton of material (productive and non-productive) extracted from mines is about 13s. 6d., and the cost of producing a flask of quicksilver about £5 5s. 6d.

The produce of quicksilver is only about 20 pounds per ton of ore, and the profits realised in 1888 was £65,745.

M. W. B.

## THE CAPELL VENTILATING FAN.

*Uber einen neuen Grubenventilator (Patent Capell). Glückauf, Vol. XXIV., 1888, pp. 785-6, one figure.*

Mr. Herbst has recently made the following experiments upon a Capell Fan, 36 inches diameter, 12 inches wide, with an inlet pipe 6½ feet long, and 19¾ inches diameter. The internal drum has a diameter of about 20½ inches, and is fitted with 6 inner and 6 outer vanes.

| No. of Experiment. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revolutions per minute. Engine. | 65 | 72 | 41½ | 50 | 57½ | 92 | 79 | 71 | 90 | 87 | 99 | 77 | 90 | 104 | 112 |
| Revolutions per minute. Fan. | 601 | 651 | 378 | 456 | 527 | 840 | 717 | 643 | 813 | 793 | 897 | 690 | 839 | 967 | 1,043 |
| Water-gauge in inches | 1·016 | 1·272 | ·413 | ·578 | ·795 | 2·142 | 1·854 | 1·161 | 1·929 | 2·362 | 3·130 | 2·283 | 3·307 | 4·628 | 5·118 |
| Difference of pressure in the Pitot tubes in inches. | ·3072 | ·3678 | ·1301 | ·1801 | ·2379 | ·7244 | 1·1830 | 1·1830 | 1·8326 | ·5925 | ·8327 | — | — | — | — |
| Weight of one cubic foot of air in pounds. | ·07569 | ·07565 | ·07580 | ·07577 | ·07573 | ·07548 | ·07554 | ·07566 | ·07563 | ·07544 | ·07529 | — | — | — | — |
| Velocity of air in feet per minute. | 2122 | 2323 | 1380 | 1624 | 1867 | 3263 | 2906 | 4165 | 5189 | 2952 | 3503 | — | — | — | — |
| Volume of air in cubic feet per minute. | 4486 | 4909 | 2917 | 3432 | 3946 | 6897 | 6141 | 8808 | 10970 | 6240 | 7405 | — | — | — | — |
| Weight of air per minute in pounds. | 339·5 | 371·5 | 221·1 | 260·1 | 298·9 | 520·7 | 463·9 | 666·3 | 828·3 | 470·7 | 557·5 | — | — | — | — |
| Work of compression in horse-power. | ·7176 | ·9850 | ·1899 | ·3129 | ·4944 | 2·324 | 1·792 | 1·610 | 3·329 | 2·318 | 3·643 | — | — | — | — |
| Vis viva or work in the air in horse-power. | ·2000 | ·2620 | ·0560 | ·0896 | ·1363 | ·7261 | ·5124 | 1·512 | 2·917 | ·5366 | ·8048 | — | — | — | — |
| Useful effect of the Fan in horse-power. | ·5176 | ·7210 | ·1349 | ·2233 | ·3681 | 1·599 | 1·260 | ·0986 | ·4128 | 1·782 | 2·748 | — | — | — | — |
| Indicated horse-power of engine. | 1·977 | 2·613 | ·709 | 1·072 | 1·490 | 4·516 | 2·961 | 2·431 | 4·602 | 3·489 | 5·066 | — | — | — | — |
| Useful effect of the Fan per cent. | 26·17 | 28·7 | 19·03 | 20·83 | 24·04 | 35·41 | 43·23 | 4·06 | 6·97 | 51·08 | 54·25 | — | — | — | — |
| Condition of Entry of Air. | Wire gauze over the orifice. | | | | | | | | Full. | Open. | Much contracted. | Orifice closed. | | | |
| Contraction of orifice. | Almost | 45 per cent. | — | — | — | — | — | — | — | — | About 50 per cent. | — | — | — | — |
| Equivalent orifice in square feet. | 1·716 | 1·678 | 1·750 | 1·740 | 1·706 | 1·815 | 1·737 | 3·150 | 3·041 | 1·563 | 1·609 | — | — | — | — |

M. W. B.

## IMPROVEMENTS IN WIRE ROPE WAYS.

*Neuerungen an Drahtseilbahnen.* J. Sprenger. *Berg- und Hüttenmännische Zeitung. Vol. XLVIII., No. 22, pp. 193-195, 1 Plate.*

Most wire rope ways in Germany have the tubs hung each from a single cross-bar on one side of a pair of wheels which run on the fixed rope. At the Hostenback Colliery in the Saar basin double cross-bars have been introduced, and the tub is hung from a bolt passing through both of them. The spindles of the wheels thus get a bearing on each side and the wear is evenly distributed.

The wheels are of steel, and the hollow axles of phosphor-bronze. Grease is put into the axles through holes in their ends and these are filled up by screws. The heat caused by running melts the grease slightly, and it runs through radial holes on to the rubbing surfaces.

These axles are easily replaced, and spare ones of varying sizes are kept at the different stations, but the wear is found to be very slight. The lubrication is unaffected by frosty weather. The grease is put in through a syringe holding enough for 30 or 40 wheels, and scarcely any of it is lost in the operation.

The hauling rope has steel rings or "knots" on it at intervals, and there is a fitting on the tub composed of a wheel over which the rope runs and double pawls to catch the knots. The tubs are made to free themselves automatically at the stations by diagonal bars which lift up the pawls, and they move on to the sidings by their own momentum. A. R. L.

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## GOLD MINING IN TRANSYLVANIA.

*Studien über den Goldbergbau und die Goldgewinnung in Siebenbürgen.* E. Thilo, *Berg- und Hüttenmännische Zeitung. Vol. XLVIII, Nos. 14 and 15, pp. 125-129, and 133-137.*

The gold mining centres in Walachia are the little towns of Brád, Abrudbaňya, and Zalatna, which lie at considerable distances from railways, and are approached only by very bad roads. The mines were worked for a time by the Romans and were again opened during the Middle ages. They are not very rich, and the modern workings are mostly extensions of earlier mines, the most promising parts of which have been worked out.

Gold occurs almost everywhere over a considerable district, but only here and there in paying quantity.

It is found chiefly among the quartzy and sparry filling matter of caverns and veins, and but seldom in nuggets.

The percentage of gold in such veins varies and is difficult to determine, but it seldom reaches an average of ·003 per cent.

For separating the gold, the commonest and most paying workings are the small peasant crushing mills. An overshot water wheel drives from 6 to 12 square wooden stamps, each from 4 feet 6 inches, to 6 feet long, and shod with iron. The stamping trough is of wood, lined with iron, or it is made up of pieces of basalt, as are sometimes also the stamps, The ore is shovelled into the trough, and a stream of water allowed to run through. The stamps not only crush the ore, but at the same time cause the lumps to rub against each other, and the particles of gold contained in them are thus gradually released. Each stroke of the stamp causes a wave of muddy water to flow out, either into a sump, in which the heavy gold particles sink to the bottom, or over an inclined surface covered with cloths, which act as sieves, and are at intervals changed and washed out.

Most of the gold remains in the stamping trough, and the stamping is stopped at intervals and the crushings are taken out and put through a fine sieve. The sieve is then examined for larger lumps of gold, and the powder, as well as the yieldings of the sump or cloths, is taken to the gold-hearth to be further worked.

The gold-hearth consists of a wooden surface, set at a slight inclination, over which a small stream of water is conducted, and the powder is laid on in the form of a trough and shovelled up against the stream till only the heavy gold and gold-bearing matter remain. Below the hearth is a cloth to filter the escaping muddy water, and the solid matter thus caught is worked over again. The free gold is separated from that mixed with other substances in a thin wooden trough, shaped in plan something like the side view of a bell, and rounding up to an edge at the broad end.

The manipulator, by adding water and giving the trough a circular jerky motion, is able to bring the heavier particles, which are the pure grains of gold, into a corner by themselves, so that by the addition of quicksilver they can be formed into amalgam, which, heated to a sufficient temperature, yields gold melted into one lump.

Twelve stamps will crush only 4 tons of ore in a week, and this method is, therefore, unsuitable for the larger companies, which employ several well-known machine methods, mostly borrowed from America.

The relative cost of crushing by the various methods is :—

| | s. | d. | |
|---|---|---|---|
| Californian Crushing Machinery ... ... ... | 5 | 9 | per ton. |
| Crushing by Wooden Stamps, with Quicksilver Mills | 2 | 10½ | ,, |
| ,, New American Roller-Mill ... ... | 1 | 11 | ,, |
| ,, Ball Mill, with Quicksilver Mills ... | 1 | 5 | ,, |
| Peasant Crushing (described above) ... ... ... | 1 | 11 | ,, |

Gold stealing is carried on to a considerable extent in the larger mines, and this partly accounts for the relative smallness of their gains. A. R. L.

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## LEAD SMELTING IN PERU.

*Die Gewinnung von hoch silberhaltigem Werkblei durch die Indier Perú's, Sn., Berg- und Hüttenmännische Zeitung. Vol. XLVIII., No. 19, pp. 165-6.*

In certain districts of Peru, there is still practised a rough method of lead smelting, which is known to have been used by the Indians from very early times.

The ore used is more or less clean, rough, lead glance containing a high percentage of silver. Occasionally fahl-ore is added to increase the proportion of silver, and quartz or chalk to produce a liquid slag.

The melting furnace is round in plan with a cupola-shaped top, and the hearth is basin-shaped, and lined with greyish-white talcose clay. The building material is sun-dried brick made of clay and dry grass. On one side of this erection is a rectangular heating furnace, and on the other a flue leading out to a chimney about 13 to 16 feet in height. The furnaces are covered with turf to keep in the heat. The diameter of the melting furnace is about 3 feet, and its height above the edge of the hearth rather less. About a foot above the hearth is a large flame opening, the working door being opposite, just above the hearth, and a smaller door near it at one side. The walls are built up round a heap of loose earth formed to the required shape, and this is shovelled out after the brickwork is dry.

The heating furnace is of oblong shape with a long side next the main structure, and it stands by itself on rows of bricks or stones. Its arched top is built over a mould of brushwood and turf, which is afterwards burnt out. It has a door at each end, one to admit fuel and the other for cleaning. The fuel used is brushwood and dried cow-dung.

After the apparatus has become red-hot the lead glance is put in, the weight of a charge, including fahl-ore, being from 200 to 220 lbs. The working door is kept open, and after the lead has melted and run into the base of the hearth, the slag is removed through it. The pool of lead is then left to simmer, and a hard smooth scum gradually forms on the top, which is then broken up and also removed. The mass is by this time reduced by about two-thirds, and the furnace being allowed to cool the remaining one-third, the "metal ring," is broken out and sold or bartered.

The process occupies from 6 to 8 hours, and, with intervals for cooling, the apparatus can be used from 4 to 6 times but requires considerable repair each time. The loss of silver is very great, and the author has found it in quantities of from ·12 to ·18 per cent. amongst the slag, and of ·05 per cent. amongst the scum. About six or more Indians are engaged in the work, and divide the profits amongst them. A. R. L.

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## DRESSING ORE-ROLLS IN POSITION.

*Vorrichtung zum Abdrehen der Walzen bei Erzwalzwerlsen.* *By* — LUTTERMANN. *Berg- und Hüttenmännische Zeitung. Vol. XLVIII., No. 16, p. 141, 1 Plate.*

As rolls for ore-crushing require to be kept cylindrical, it is customary to encase them in so-called bandages, which are periodically taken off and replaced by other new or newly turned ones, causing a general stoppage of the machinery. To obviate this, Herr Luttermann has adopted an arrangement, by which the bandages can be turned in place. Half-way between the axes of the rolls, and parallel with them, a cross-bar is fixed on to the upper part of the framework, and on it a cutting tool slides from side to side. A rod with a jaw at each end is put between the spindles on each side, and the buffer springs are similarly wedged rigid, so that the rolls are firmly fixed, and all play taken up.

The large flywheel is fitted with teeth, and works into a small toothed wheel on a shaft behind, which is thrown out of gear during ordinary work. By this means the necessary reduction of the speed is effected without the engines or the rest of the machinery having to be stopped.

The cutting tool is pushed across by hand, and it is reversible on the slide so that it can act on either roll.

The arrangement has in several mills been successfully applied. A. R. L.

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## SETTLING PONDS USED IN ORE AND COAL WASHING.

*Ueber die Anlage von Klärsümpfen bei Erz- und Kohlenwäschen.* *By* R. WABNER. *Berg- und Hüttenmännische Zeitung. Vol. XLVIII., No. 17, p. 149.*

Settling ponds often form part of ore and coal-washing plant, either in order that the water may be used again, or on account of police regulations. In these it is common to see a deep narrow stream of dirty water let in at one end of a rectangular tank, and a similar stream flowing out at the other end.

Herr Wabner shows, that, with this arrangement, a compact stream rushes through the tank, often without being properly cleansed, while the water at each side remains undisturbed.

He recommends the inlet to be arranged so as to flow in a shallow sheet over the whole end of the tank at once, the cleared water flowing over the further end in like manner. By this means only the topmost and cleanest stratum of water is allowed to flow off, and the greatest possible effect is obtained.

Herr Webner has invented a machine, which he does not describe, which reduces the cost of removing the muddy deposit in such tanks to a tenth of that which its removal formerly entailed. A. R. L.

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## ARTESIAN WELLS IN SAXONY.

*Ueber artesische Brünnen in Sachsen.* Dr. Richard Beck. *Berg- und Hüttenmännische Zeitung. Vol. XLVIII., No. 5, pp. 39-42.*

In March last, two strong Artesian wells were bored in Saxony, the first one in a brick factory, at Zehista, near Pirna; and the second one in the Barracks close to Pirna itself.

An Artesian well is one in which the water, after the stratum containing it has been tapped, rises to the surface by hydrostatic pressure, and the name is traced to the province of Artois in France, whence the knowledge of such wells was first spread abroad.

The conditions under which they become possible are, a stratum of sand, gravel, chalk, or other porous substance between two non-porous ones, without faults or troubles, lying at a steep angle, with outcrops at a considerable elevation where water can collect and sink in. Paris lies in a basin-shaped valley which is peculiarly suitable to this purpose, and London has increased the number of its Artesian wells till the former strong pressure has become very much reduced.

A boring section of a well in Dresden showed the following :--

| | Ft. |
|---|---|
| Sand and Gravel ... ... ... ... ... ... ... | 53 |
| "Pläner" (non-porous, cretaceous) ... ... ... ... | 735 |
| Grey Sandstone ... ... ... ... ... ... ... | 10 |
| Total ... ... ... ... ... ... ... | 798 |

Lower stratum unknown.

The water is supposed to come from some hills about six miles to the south of Dresden, and the seam containing it is the Shauklin Sand, which also yields the supply at Pirna.

The boring at Zehista gives the following :—

| | Ft. |
|---|---|
| Clay and Soil ... ... ... ... ... .. ... | 38·2 |
| Yellow Sandstone ... ... ... ... ... ... | 65·2 |
| Sandy Marl ... ... ... ... ... ... ... | 51·5 |
| White Porous Quartz Sandstone ... ... ... ... | 3·6 |

While the last bed was being bored the water suddenly spouted up, and on a narrow pipe being fitted over the hole, rose to a height of 23 feet. In this case the water, though welcome for supplying the boilers, was unfit to drink.

The section at the Pirna Barracks was :—

| | Ft. | |
|---|---|---|
| Earth and Clay ... ... ... ... ... | 39·5 | |
| Green Sandstone (compact) ... ... ... | 32·0 | |
| Porous Green Sandstone ... ... ... | .3 | Water No. 1. |
| Marl ... ... ... ... ... ... | 13·1 | |
| Porous Green Sandstone ... ... ... | ·7 | Water No. 2. |
| Green Sandstone (compact) ... .. ... | 14·1 | |
| Marl ... ... ... .. ... ... | ·7 | |
| Fine Calcareous Sandstone ... ... ... | 187·0 | |
| Coarse Porous Quarz Sandstone ... ... | 41·5 | Water No. 3. |
| Medium rather porous Quarz Sandstone with mixture of Iron Pyrites and Carbonaceos substances .. ... ... | 49·3 | |
| Total ... ... ... ... | 378·2 | |

Water No. 2 rose above the edge of the bore-hole, and water No. 3 rose through a narrow pipe to a height of 40 feet, giving 12 gallons per second.

The Shanklin Sandstone, which is the water-bearing seam in each of these cases, has a dip of from 2 to 3 degs. to the north-east, and the place where the water enters it must be looked for to the southward. The water No. 2 in the Pirna Well may be traced to a stream in the Gottleuba Valley, about 5 furlongs to the south of the barracks.

In considering the question whether further wells may be discovered in other districts of the Elbe Valley, Dr. Beck professes himself unable to do more than indicate the geological "probability" of it. A. R. L.

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## QUICKSILVER IN TUSCANY.

*Sur les Gites de Mercure du Monte Amiata. By* — PRIMAT. *Annales des Mines, Series 8, 1888, Vol. XIV. pp. 95-130, and Plate IV.*

The mining district of Monte Amiata is situated in the province of Grosseto, near the railway station of the same name on the line from Grosseto to Sienna.

The Penna mountain consists, beginning at the top, of the following strata : a circular belt of nummulitic and madreporic limestone of Eocene age ; marly manganiferous shales and limestones of very fine texture and containing calcite in the numerous fissures ; marly non-manganiferous limestones : the principal deposits of cinnabar are found in these limestones in irregularly distributed masses of irregular form ; greyish madreporic siliceous beds : small veins filled with very pure cinnabar form an irregular network in these siliceous beds ; marls and limestones, similar to alberese limestone, with a network of fissures filled with calcite.

The cinnabar is found in beds and veins. At Siele, the small irregular veins were followed downwards, and at a depth of 360 feet, the most valuable deposits of cinnabar were found in the marly limestones. At Cornacchino the small veins in the siliceous rocks were followed upwards until the deposits were found in the limestones. Usually the clays, impregnated with cinnabar, fill the irregular cavities in the marly limestones ; but it is not usual, at Siele, to find blocks of pure cinnabar of 30 cubic feet. The proportion of cinnabar in the clays is sometimes so small that the ore is only discerned by rubbing the surface of the clay so

as to break the particles of cinnabar and produce a red colour. The cavities appear to be all in inter-communication, and sometimes contain a brecchia of limestone and clay.

The clay is sometimes filled with a network of small veins of cinnabar. The cinnabar is sometimes accompanied by sub-sulphates of mercury ($Hg_2$ S) known as "neri," and native mercury. Iron pyrites and gypsum is associated with the cinnabar in the clays but not in the veins.

Deposits of stibnite (tersulphide of antimony) are found associated with the cinnabar.

The percentage of mercury varies from 2 to 30 per cent. in the mineral, and is concentrated up to 25 or 35 per cent. The ore is washed with rakes in small rectangular boxes. The mineral is then mixed with about 20 per cent. of quicklime, and placed in retorts and heated ; the mercury which distills over is condensed. The plant appears similar to that used for gas making. One ton of wood is used per ton of mineral, and each operation lasts about seven hours.

The wages paid for 12 hours shifts (less intervals for meals) are : miners 1s. 3d., labourers 1s., timberers 1s. 8d., waggonmen 1s. 8d., women 6d., and an allowance of 2d. per day to each miner for lamp oil.

The produce of mercury has been : in 1873, 116 tons ; 1876, 111 tons ; 1877, 130 tons ; 1878, 115 tons, and the production has since gradually increased to 237 tons in 1885.

The cost of production is about £60 per ton, or say 6½d. per pound, and the selling price in London varies from 1s. 6d. to 2s. per pound. M. W. B.

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## OZOKERITE AND PETROLEUM IN GALICIA.

*Sur l'Ozokérite de Boryslaw et les Pétroles de Sloboda.* *By* L. Babu. *Annales des Mines, Series 8, 1888, Vol. XIV., pp. 162-196, and Plate V.*

### Ozokerite.

The deposits of ozokerite, at Boryslaw, were recently described by A. Rateau (see abstract, Vol. XXVII., pp. 55-56). In an area of about 250 acres, divided among about 1,200 owners, there are from 12,000 to 13,000 pits, of which about one-tenth are now working. The pits are from 3 to 8 yards apart, and each works an area of from 9 to 64 square yards. The pits are square, and ordinarily, have a section of about 10 square feet, and when they encounter a vein or bed of ozokerite, a drift is driven on it, if possible into the adjoining property, until it closes by a fall.

The produce is drawn by a jack roll worked by a man or woman. The mortality from accidents is about 2 per cent. per annum.

Great danger arises from inflammable gases, which are enclosed in the strata under great pressure. Mueseler or Marsaut lamps are in universal use.

The produce is either pieces of nearly pure ozokerite or earths rich in ozokerite. After the pieces of pure ozokerite are picked out by women, the earths containing 8 per cent. are treated with cold water, and the ozokerite separates, owing to difference of density. After this washing, the earths containing 4 to 5 per cent. are placed in casks and boiled with water, the ozokerite floating to the surface at a temperature of 212 degs. Fah. It is proposed to treat the residue containing from 1 to 1½ per cent. of ozokerite with benzine, so as to remove the last traces, and remove the benzine by means of steam heating.

The pure ozokerite is melted and run into loaves weighing about one cwt. The cost of washing, &c., is about 9d. per cwt.

Details are given as to costs of working, &c. In 1886, the selling price was from £20 to £25 per ton, and cost of production from £13 to £15, leaving a profit of from £5 to £10 per ton.

The annual production has varied from 4,000 to 18,000 tons, and in certain years the value has exceeded £360,000.

Other deposits of ozokerite are found at Truskawice, Starunia, and Dwniacz, always in Miocene formations.

### Petroleum.

The most celebrated petroleum region of the Carpathians is at Slobodarungurska, about three miles from Kolomea. It is probable that oil issues from Eocene formations, although certain geologists consider that they are of Miocene age. The workings are concentrated in a clearing, in the bottom of a valley, and surrounded by the state forests.

Beneath the alluvial deposits of sandy clays, the boreholes traverse a series of beds of shales and sandstones, dipping towards the south-west. The sandstones are the only beds impregnated with the petroleum, and down to a depth of 300 yards there are three of these oil-bearing horizons; the petroleum is also found in the faults.

The mining area covers about 800 acres, and all pits sunk to a certain depth in this area are productive. The oil is worked by means of boreholes, which were first made by hand labour, but the Fabian and Canadian systems of boring are now universally adopted (full details are given of these two systems).

The mean produce of a well is from 25 to 30 barrels per day, and the life of a well is about two years. The holes are usually not less than 20 yards apart. The total production of a well is from 15,000 to 20,000 barrels. The annual production of the district is about 750,000 barrels.

The densities of the oils diminish in depth; when shallow it may be 38 degs., with 6 per cent. of paraffin; at some depth it may be 35 degs., with only 1 per cent. On distillation the oil yields—

| | |
|---|---|
| Benzine ... ... ... ... ... ... ... ... | 22 |
| Lighting Oils ... ... ... ... ... ... . . | 56 to 60 |
| Paraffin ... ... ... ... ... ... ... ... | 1 to 6 |
| Residues and loss ... ... ... .. ... ... | 12 |

The royalty paid to the owner of the oil is usually 50 per cent. of the produce. The price of a barrel is about 10s., and in a well with an average output and duration, the gross produce will be worth from £7,500 to £10,000. The cost of boring (£1,850), maintenance for two years (£185), attendance (£880), and sundry charges (£385), may be estimated at £3,300.

The royalty at 50 per cent. will vary from £3,750 to £5,000, and the net profit from £450 to £1,700. M. W. B.

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## THE KLINIK SAFETY-CATCH FOR CAGES.

*Die Klinik 'sche Fangvorrichtung für Förderschalen.* Richard Luders. *Berg- und Hüttenmännische Zeitung. Vol. XLVIII., No. 12, pp. 107-109. Illustrated in the text.*

The object of this invention is to prevent the sudden jerk which accompanies the action of ordinary safety catches.

The cage being suspended by the usual four chains gathered into a central ring on the end of the rope, a long vertical bolt carrying a strong spiral spring is attached to the ring in addition, and by means of a strong eye with arms fixed to the framework, the spring is arranged to be drawn up when the rope is taut. Diagonal rods with their upper ends hinged, below the spring, to the bolt, and their lower ends, actuating what are practically the arms of a pair of bell-cranks standing so as to look like the letter X, cause the legs of these to approach each other when the spring is released.

The arms of these so-called bell-cranks, if looked at from the ends of the cage, are seen to be rods fixed to parallel bars some 12 inches to 18 inches apart, set in bearings at each side of the structure. The legs are fixed to these rods at the sides of the cage, besides the guides, and contain the important part of Herr Klinik's invention. Each of them, for perhaps 2 feet in the centre of its length, is arranged with slots at right angles to each other, and a toothed disc on a short toothed spindle is free to move up and down in a corresponding ratchet on the outside of one of the slots, so that the rim of the wheel is towards the cage-guide.

The lower ends of the legs are not fixed, but work on loose bolts with vertically elongated holes. The bolts themselves work loosely in holes, shaped like inverted Ls in plates riveted to the framework of the cage.

In case of the rope breaking, the action is as follows:—The spring, being released, presses downwards on the diagonal rods, which, acting on the bell-crank arrangements, force the arms outwards and the legs nearer the cage-guides.

The loose bolts then travel sideways, and fall into the back pieces of the inverted L holes, fix the legs in positions nearer the guides. Meanwhile the toothed discs are thus made to press against the guides and run up the long slots, gradually tightening their grip until the cage is brought to a standstill. A. R. L.

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## THE COAL MINING INDUSTRY OF LOWER SILESIA.

*Der Jahresbericht des Vereins fur die bergbaulichen Interessen Niederschlesiens für 1887-8. Glückauf, pp. 225-227, Essen, April, 1889.*

The year 1888 is described as having been rather favourable for the Lower Silesian collieries, as enquiry for coal and coke was brisk, and a slight improvement took place in prices, which for the last ten years had been continuously going down.

Bitter complaint, however, is made of the pressure, firstly of British competition, and secondly of the rivalry of the *Upper* Silesian Coal District. It would seem that, favoured by differential railway rates, the Upper Silesian coal, though less suitable for manufacturing purposes than Lower Silesian coal, is pushing the latter out of its natural markets. But railway rates are not the sole disadvantage with which the Lower Silesian collieries have to contend: the cost of mining is great, for the seams are won only at considerable depths, and often expensive plant has to be erected for the purpose of cleaning and otherwise preparing the coal for sale.

The condition of the miners is said to be satisfactory. At one time they were tempted by "touts" to migrate in large numbers to Westphalia, but they found that the slightly higher wages there were more than counterbalanced by higher prices of necessaries, and, as a consequence, the migration from the Lower Silesian Coalfield has now stopped.

Both the great Silesian Coalfields suffered during the past year from the insufficient supply of empty trucks on the local railways, but a large increase in

rolling stock has been promised for this year by the Minister of Public Works, who has the management of the State railways. The same functionary has been urgently petitioned to abolish the Mining tax, and it is claimed that he has promised to do so shortly. L. L. B.

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## THE BILBAO IRON ORE DEPOSITS.

*Barcelone-Bilbao, Notes de Voyage.* By E. GRUNER. *Mém. de la Soc. des Ingénieurs Civils, Février, 1889, pp. 228-236. Paris, April, 1889.*

After the customary description of the different varieties of Bilbao iron ores, *campanil*, *rubio*, and *vena*, the author proceeds to discuss their probable origin. With him the key to the puzzle is found in the theory of thermal springs at successive periods, and of varying character, giving rise to many chemical reactions, and in some cases altering the deposits already formed. In this way, he shows that the campanil dates from Upper Cretaceous times, and that the rubio has been formed well within the Tertiary period. L. L. B.

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## EARTHQUAKES IN MINES.

*Propagation du tremblement de terre dans l'une des mines d'Anzin (Nord).* By M. FRANÇOIS. *Comptes Rendus, 1887, Vol. 104, pp. 661-2.*

A tromometer is placed in the Herin Colliery (belonging to the Anzin Coal Co.), at a depth of about 830 feet. On February 23, 1887, between 6·15 and 6·30 a.m., the instrument was greatly disturbed, the amplitude of the movements being about ·05 inch, the greatest movement previously observed, on January 6, being about ·008 inch.

Note.—This was about the time of the great earthquakes at Nice, of the same date. M. W. B.

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## EARTHQUAKES AND FIRE-DAMP IN MINES.

*Tremblement de terre et grisou.* By F. A. FOREL. *Comptes Rendus, 1887, Vol. 104, pp. 833-4.*

An earthquake is a complicated phenomenon, and comprises:—(1) The preparatory microseismis movements, whose significance is obscure; (2) the shock, caused by a rupture of the rocks, by a fracture or folding of the strata, a sliding of the two sides of a fault, or other similar cause; and (3) the consecutive shocks which may last for days, and even months.

If this interpretation be correct, there is a tendency to develop microseismic movements in the area of the great shock, and if these movements can liberate reservoirs of gas, the miner should increase his precautions against the presence of gas in the days following an earthquake, as the area of disturbance may extend to mining districts. M. W. B.

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## GEOLOGY OF THE LOWER CONGO.

*Esquisse géologique du Bas Congo.* By H. ZBOINSKI. *Revue Universelle des mines and de la Métallurgie. Vol. VI., part I, pp. 31-39. With a geological map, Plate IV. Liége, April, 1889.*

The author first remarks that previous to his arrival in the Congo State, he went to Gaboon where he found fossiliferous tertiary limestones not far from the

coast. They are worked by the Catholic Missionaries for lime and building stone. After his sojourn in the Congo State he travelled to St. Paul de Loanda, Benguela, and Mossamedes. At all those places he noticed limestones along the coast, similar to, but apparently more recent than, the Gaboon limestone. He concludes that the hills along the coast near the mouth of the Congo are of the same geolgical formation.

The banks of the Congo are at first comparatively flat, but 12 miles below Boma they become steeper and gradually rise to the height of 900 feet at Leopold Rock, which towers 400 feet above the settlement of Vivi. The rocks forming these steep banks are chiefly quartzites containing abundant tourmaline, but on the left shore, just where the rise from the plain begins, the granite mass of the Fetish Rock is seen. On Leopold Rock there is a vein of magnetite which varies in thickness from 8 to 16 inches. From Vivi all the way up river to Issanghila micaschists predominate. Dips are generally high, varying from 45 degs. to 60 degs, and the strike at first east and west, changes to S.E., and N.W.; but a few miles below Issanghila, the beds are nearly horizontal. Green quartzites are often seen in the river bed, and from the falls of Yellala and Issanghila. Kaolin very nearly pure is found in great abundance a few miles west of Issanghila.

Above Issanghila, the banks are much lower. Among the rocks which now crop out is a compact grey sandstone (honestone), from which the natives quarry pieces to use for barter. Quartz schists occur, sufficiently tough and fissile to form slates. Then the banks rise again, the beds become vertical almost, until the falls of Kilolo are passed. Above Baynesville Falls, the rocks are chiefly calc schists (*sic*), interbedded with extremely siliceous limestone, on a plateau of which the British Missionary Station is built. Soon after the quartz schists appear again with changing dips, and then give place over a large area to violet clay slates, up to Lukungu and Manyanga. Near Manyanga South Station, rises a quartzite plateau of considerable height, on which the author found stone implements. Immediately to the east of this, the rocks change to red sandstones alternating with lighter red clay slates; a formation which, according to the late Captain Hanssens, continues up to Stanley Pool. Generally speaking, the rocks surfaces in the Lower Congo are covered by detritic masses of Laterite, which often attain a considerable thickness forming entire hills and covering large areas. L. L. B.

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## CANNEL COAL IN ALASKA.

*The Colliery Engineer, 1889, Vol. IX., p. 197.*

Coal is found at Coal Harbour, the outcrops of three seams being found in a sandstone formation, in the face of a perpendicular cliff. The dip is to the north-west, at about 3 degs. to 5 degs., and soon carries the seams under the surface of the bay. The lower seam is about 8 feet, the middle from 4 to 5 feet, and the third about 3 feet. The coal is a very fine cannel, and suitable for smiths' use.

An analysis gave:—

| | |
|---|---|
| Carbon | 86 |
| Hydrogen | 7 |
| Ash | 6 |
| Sulphur | trace. |

Coal is also found at Coal Bay in Graham's Harbour, at Cook's Inlet, and is exposed all along the eastern shore of the inlet from Anchor Point at the northern entrance of Kachemack Gulf to Kusiloff River, and at various points between Coal Harbour and Graham's Harbour, a distance of 100 miles. M. W. B.

## A MECHANICAL SLATE-PICKER.

*The Colliery Engineer, 1889, Vol. IX., p. 207.*

A common chute having a sheet-iron bottom is placed beneath the screens, and into this the coal and slate fall. Four or five feet down the screen, the bottom bulges up into a sort of ridge crosswise of the chute. The sliding pieces of coal and slate are slackened in their speed by this ridge. Just below the ridge, there is a hole through the bottom of the chute, crosswise and six or eight inches wide. Beyond this opening, the bottom of the chute consists of a piece of sheet-iron, which may be moved so as to leave the opening narrower or wider. This piece may also be raised and lowered. The sliding pieces of slate being heavier and rougher than the coal, move more slowly, and on striking the ridge are slackened in their speed, and drop through the opening. The coal being lighter and more glassy, slides so swiftly as to jump the opening, and continues down the chute into the bunkers. M. W. B.

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## THE PELTON HIGH-PRESSURE WATER WHEEL AND DYNAMOS ON THE COMSTOCK.

*The Engineering and Mining Journal (New York), Vol. XLVII, 1889, p. 320, and one figure.*

The installation at the Nevada Mill has been in operation for some time. The six Pelton wheels, 40 inches in diameter, are attached direct to the shafts of the dynamos, and run at 900 revolutions per minute when loaded, and at 1,800 revolutions when unloaded, the water flowing from the nozzle with a velocity of 19,260 feet per minute, under a head of 1,630 feet. The mechanical efficiency is from 88 to 90 per cent. Forty stamps, with their complement of amalgamators and concentrating apparatus, are now being run with about 120 inches of water, running it first over the wheel on the surface, and then down the shaft in pipes to the lower wheels.

Before the motors were in use, 300 inches of water were required to run 40 stamps, &c., hence there is a saving of 60 per cent., or 180 miners-inches of water, by the use of the electrically transmitted power.

In a test made recently, the Pelton wheel, which drove a dynamo, developed 110 horse-power, whilst the motor in the mill delivered 72 horse-power to the belt, giving an efficiency of 65¼ per cent.

Insulated wires are led from the dynamos to a switch-board situated at the foot of the incline, where any dynamo can be put on any motor, almost instantaneously. From the switch-board, the wires follow the pipe-line up the incline shaft through a short tunnel, and are carried to the motor house, and connected with each of the motors, developing (75 × 6 =) 450 horse-power. The power is carried a distance of 2,800 feet. M. W. B.

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## THE SAUNDERS BAR CHANNELER.

*The Engineering and Mining Journal (New York), Vol. XLVII, 1889, p. 347, and one figure.*

This is a machine intended for cutting "channels" and boring holes in stone quarries. It consists of an "Ingersoll" or "Sergeant" drill, with variable stroke, mounted on a pair of parallel bars, each of whose ends are fitted with two adjusting screw legs.

In use, two holes are bored at the end of the bar, and a cross-head and clamp carrying the chisel is inserted and the "channel" cut between the two holes. After the "channel" has been cut to the required depth, the machine is moved along so as to extend the cut as required. The machine is arranged to strike about 250 light blows per minute, and is said not to "jar" the stone, which is marketable up to the very face of the "channel."

A machine will cut about 1,400 square feet of "channel" per month, and to a depth of 10 feet, with one man and a labourer to run it. M. W. B.

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## PERMEABILITY OF CEMENTS AND MORTARS.

*By* L. M. Haupt. *The Engineering and Mining Journal (New York), 1889, Vol. XLVII., p. 393.*

Experiments showed that about 17¼ gallons of water per square foot of surface passed through a thickness of nearly 16 inches of cement in 24 hours, under a pressure of 77 pounds per square inch.

Under a pressure of 72 pounds per square inch, water percolated through a dam of bricks laid in cement 4 feet thick, in a tunnel 10 feet by 10 feet, at the rate of 120,000 gallons, or 1,200 gallons per square foot per day.

Water under 36 feet head was found to percolate through 26 inches of brickwork, and 4 feet of concrete.

A good fair specimen of brick was taken, and under a pressure of 80 pounds per square inch passed 23·4 cubic inches of water per hour, and when under trial for a second hour it passed 21·3 cubic inches of water. The average of these experiments being 2·8 cubic inches of water per square inch of exposed area of the surface of the brick, which is equal to 1·75 gallons of water per square foot of surface per hour.

With another brick, in the first hour under 80 pounds pressure, 46·8 cubic inches of water passed through, and for the same brick in 16 hours, under 53·8 pounds pressure per square inch, 344·5 cubic inches of water passed, equivalent to 1·68 gallons per square foot of surface per hour.

Blocks of cement, one of cement to two of sand, under a pressure 80 pounds per square inch, passed in 2½ hours, 2,367·8 cubic inches of water, equivalent to 73·8 gallons per square foot per hour. Under 58 pounds pressure per square inch for 1½ hours, 874·8 cubic inches passed, equal to 45·5 gallons per hour per square foot of surface. M. W. B.

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## GOLD AND OTHER MINES IN COREA.

*Ueber Gold vorkommen und Bergbau in Corea.* C. Illing. *Berg- und Hüttenmännische Zeitung. Vol. XLVIII, Nos. 1, 2, and 3, pp. 1-3, 12-15, and 23 to 26.*

In the course of a geological tour through Corea, Herr Illing visited several gold workings and obtained information about mines of copper, iron, and coal.

The principal mountain range in the Peninsula runs from north to south along the east coast and has several low off shoots at right angles to it trending towards the west, crossed again in places by low chains of hills running parallel with the main range.

A network of valleys and ravines is thus formed, and in some of these, in the province of Pingyands to the northward of Söul, the capital, are found both reef and alluvial gold. Herr Illing visited two mines of reef gold near the towns of Unsan and Wunsan respectively.

The gold-bearing seam in the first case is a bed of Gneiss which gradually merges into quarzite, overlaid in places with boulders said to be also "gold-bearing." The reef is about 39 inches thick and is worked by two day drifts, each about 6 feet 6 inches square, by about 22 yards long. The method of winning is to light a fire at the face, causing the stone to crumble; then, after giving the drift time to cool, to bring down as much reef as possible with hammers and little round steel wedges. The reef is broken into pieces of about walnut size, crushed under a heavy stone block, ground still finer between two hard stones, and then washed in a neighbouring brook. The mean percentage of gold in the stone is about ·01, about half of which is lost in working. The Coreans know neither pump nor syphon, and if much water is encountered, their work is brought to a standstill.

About 50 miles north of the same town there are extensive fields of alluvial gold, worked in very primitive fashion by the Coreans. The workings visited by Herr Illing were carried on in wet sand. The yield varied very much, but was occasionally rich.

In the Wunsan district, the most northerly visited, gold-bearing quarz reefs are known to exist for about $7\frac{1}{2}$ miles along a valley running north-west from the town. Alluvial gold is also found and worked at various points up the same valley for about 15 miles. The reef is worked at two points about three miles apart, and its thickness is from 20 inches to 40 inches in the one case, and from 12 inches to 20 inches in the other. Specimens from the thicker reef yielded about ·017 per cent. of gold, and one from the thinner one only ·002 per cent.

Copper mines exist in other provinces, and were formerly worked, but the Coreans, having exhausted the outcrops, were unable to undertake deep workings, and they were, in consequence, abandoned, the copper for coinage being now imported from Germany.

Iron ore has been worked in Corea from time immemorial, and coal has been won in the southern districts for many years. A new coalfield has lately been discovered in the north-west of the Peninsula, in the Pingyang district. The coal is an anthracite, with from 5 to 6 per cent. of ash, and is considered as good as that brought from China. It occurs in three seams, each about 5 feet thick.

The Corean Government has hitherto placed obstacles in the way of European mining; but could this exclusiveness be overcome, the country would afford a good field for this, as for many other engineering enterprises. A. R. L.

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## OBSERVATIONS ON THE FURNACE AND FAN, AND MINE VENTILATION.

*By* G. M. Williams, *Inspector of Mines. The Colliery Engineer (Scranton, U. S.), 1889, Vol. IX, pp. 219-220.*

A forcing fan producing a ventilating pressure, equal to one inch of water-gauge, was changed to an exhaust fan producing a pressure of one inch of water-gauge. While running at the same speed, the ventilating force developed is equal in both applications under the same conditions. The weight of air passing is the same, but owing to the difference of density there is a slight difference in the volume of air at the fan.

When two fans of equal effective power are used to ventilate a mine in common or on the same air-ways, the ventilating pressure propelling the air through the same air-ways is equal only to the pressure produced by one fan, and the volume of air passing is only a little more than would be passing with one fan. By adding fans the propelling pressure is not increased, but the air meets less resistance in passing through two fans than through one, consequently the volume is increased in proportion to the decrease of this resistance. M. W. B.

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## THE JEFFREY AIR-FEED DRILL.

*The Colliery Engineer (Scranton, U. S.), 1889, Vol. IX, p. 220, and one figure.*

This drill consists of a small rotary engine (driven by compressed air), hung on an upright frame, with points to engage, by adjusting screws, with the roof and floor. The power is transmitted to the auger drill by means of two internally geared wheels, a feed tube is attached to the engine, with a piston feed bar from 3 to 4 feet long, having a square socket to receive the augur drill. The engine is started first, and the compressed air is then turned in to the feed tube, which forces the piston forward. By this arrangement the feed is perfectly automatic, the rate of advance depending upon the material being drilled, and all strain of the machine is avoided. M. W. B.

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## INCLINES WITH INTERMEDIATE LANDINGS.

*Sur un Système de Plancher mobile en Fer applicable à l'Exploitation des Tailles chassantes par Plan incliné et par Défoncement à simple et à double voie, au moyen de machines.* By CHARLES RUIDANT. *Revue Universelle des Mines, &c., 1888, Series 3, Vol. II, pp. 79-94, and Plate 5.*

A movable platform is hinged at the outside of the rails, and forms, when lowered down, a level surface connecting the inclined road and the intermediate landing. When the platform is raised, the road is clear for the passage of the tubs to other levels and landings. M. W. B.

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## THE BEER WIRE ROPE WAY.

*Les Transports Aëriens Système Beer.* By CHARLES RAOULT. *Revue Universelle des Mines, 1888, Series 3, Vol. III, pp. 49-65, and Plates 2 and 3.*

The Beer system has been recently applied at the blast furnaces belonging to the Esperance Longdoz Company, to convey about 130 tons of granulated slag per day of 10 hours to a distance of about 900 feet, and a vertical height of about 160 feet.

In this system, like most others, there are two terminal stations connected by carrying ropes, and an hauling rope, worked from an engine, when the way is not self-acting. The haulage rope is fitted with iron rings, which attaches the rope automatically to the tubs, and carries them along. The hauling rope is carried vertically underneath the carrying ropes; the way being straight. At the second station, the iron ring is automatically detached from the full tub, and takes hold of an empty tub to return it to the first station.

The workmen employed consist of an engineman, a workman who loads the tubs from the hopper, and a hooker-on at the first station; and a lad who tips the tubs, and a hooker-on at the second station. M. W. B.

## THE NEWCASTLE-UPON-TYNE EXHIBITION.

*L' Exposition Minière et Industrielle de Newcastle-sur-Tyne, 1887.* *By* A. Habets, *Revue Universelle des Mines, 1888. Series 3, Vol. II, pp. 105-153, 217-236, and Plates 6-8, 10-12.*

This paper, contains notes upon the industries of the Northern Coalfield, from 1837-87; on the use of explosives in fiery mines, machine wedges, lime and other substitutes for explosives, machine drills; safety lamps, electric mining lamps; mechanical haulage in mines, &c. M. W. B.

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## MANUFACTURE OF IRON AND STEEL IN ITALY.

*De l'Industrie de la Fonte, du Fer et de l'Acier en Italie et de son Avenir vis-a-vis des nouveaux Traités de Commerce.* *By* Cryriaque Helson. *Revue Universelle des Mines, 1888, Series 3, Vol. II, pp. 237-255.*

### Manufacture of Coke.

There is no bituminous coal in Italy, the coal measures found in various districts only contain anthracite of inferior quality, very earthy, and of thin section.

### Cost of Coke.

Welsh coke costs 27s. per ton, and the writer considers that, with a battery of 100 Coppée ovens, 200 tons of coke could be made daily from a mixture of Newcastle and Welsh coal, the yield being 75 per cent., at a cost of 21s. 6d. per ton.

### Cost of Pig Iron made from Elba Ore.

Taking the yield of iron at 58 per cent., three blast furnaces yielding 70,000 tons of pig iron per annum, with iron ore at 8s. 9d., coke at 21s. 6d., and lime at 3s. per ton, the cost of a ton of pig iron is estimated at 49s. The cost of a ton of English pig iron being about 59s. 6d. per ton in Italy.

### Manufacture of Briquettes.

The costs of briquettes of equal parts of English coal and Italian lignite, both at 14s. per ton, and 8 per cent. of pitch at 33s. 4d. per ton, is estimated at 17s. 6d. per ton.

### Use of a mixture of Coke and Briquettes in the Blast Furnace.

Coke has been replaced at the Montceau Blast Furnaces (Belguim), to the extent of 20 per cent., by briquettes containing 16 per cent. of volatile matter.

### Manufacture of Coke from Coal and Lignite.

Experiments have been made in Westphalia, in Coppée Ovens, with mixtures of 40 to 45 per cent. of washed coking coal, and 55 to 60 per cent. of Italian lignite (Casteani), and produced a fine, hard, porous coke, presenting all the physical characteristics required for use in the blast furnace.

### Cost of Manufacture of Coke from Coal and Lignite.

The cost of coke from equal parts of English coal at 18s. 6d. per ton, and Gavorrano lignite at 13s. 9d. per ton, is estimated at 28s. 9d. per ton.

### Manufacture of Coke from Briquettes of Coal, and from Briquettes of Coal and Lignite.

Briquettes containing 13 per cent. of volatile matter produced (at Charleroi, Belguim) at the end of 24 hours, an excessively hard and dense coke, which did not break up in the fire and require a high pressure of wind to burn it in the cupola. The yield was about 80 per cent. M. W. B.

## THE BOILER EXPLOSION AT FRIEDENSHÜTTE.

*L' Explosion des Chaudières de Friedenshütte (Silésie Prussienne). Revue Universelle des Mines, 1888, Série 3, Vol. II, pp. 200-207.*

The motive force employed at the blast furnaces required the use of 22 boilers with external fires. A common pipe took the steam from the domes of the boilers. The feed-water was from a common source, fitted with automatic valves.

The boilers were heated by the gases from the blast furnaces, whose ignition was made more certain by a small coal fire on the fire bars. The fuel was only used at the rate of about 2½ pounds of coal per square foot of grate per hour, only three firemen being employed in each shift.

Under ordinary conditions 18 boilers were in use, and 4 under repairs.

About 12·45 midnight, of June 24-25, 1887, a frightful explosion occurred, resulting in the complete destruction of the 22 boilers; 4 workmen's houses, and 2 shops were burned, and the boiler house and blowing engine house was destroyed; and in addition, 12 men were killed and 35 injured.

Careful investigations have been made into the question by the Silesian Boiler Inspection Association, the German Society of Engineers, the German Society of Metallurgists, and others.

The report of the central section of the Prussian associations for the inspection of boilers appears to be the most trustworthy of these reports.

It concludes that the explosion was wholly due to the mode of heating the boilers from the waste blast furnace gases.

When, by any circumstance, the flow of these gases is interrupted and the flame extinguished under the boilers, as soon as the unburnt gases re-enter the furnaces and meet the fresh air, they form mixtures whose ignition may cause explosion.

It may also be conceived that the shock of the explosion of these gases would destroy the bottoms of the boilers, and that the escaping water and steam would add to the force of the exploding gases. M. W. B.

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## THE MINES OF BILBAO.

*L'Etat actuel des Mines de Fer de Bilbao. By* A. Habets. *Revue Universelle des Mines, 1888, Série 3, Vol. IV, pp. 1-15, and Plate 1.*

### Bibliography.

The writer gives a list of technical and geological papers and plans descriptive of the district. All recent writers predict the early exhaustion of the mines of this region.

### Geology.

According to Yarza, the deposits of Somorrostro are due to the transformation of a limestone under hydrothermal action. Three classes of mineral are found:—campanil, rubio, and vena.

The campanil is now nearly exhausted, it formed a lenticular mass bounded by two parallel faults, and its greatest thickness of 200 feet was found in the San Miguel concession, in contact with one of these faults.

The rubio forms the escarpments which cover the campanil, limestones, and other rocks.

In certain areas the rubio is produced, like the campanil, by transformation of the limestone, but the greater area of the deposit appears to have been formed by direct geyser action, subsequent to the raising of the Pyrenees.

The vena is found in the campanil and rubio as veins of pure ore, and its formation must have been later than either campanil or rubio.

DURATION OF THE DEPOSITS.

The workable deposits cannot exceed 60 millions of tons of ore of good workable qualities. There is, however, a further quantity of carbonate of 43 per cent., which is difficult to estimate.

The produce of the district has been as follows :—

| Year. | Tons. | Year. | Tons. | Year. | Tons. |
|---|---|---|---|---|---|
| 1860 ... | 69,817 | 1870 ... | 250,357 | 1880 ... | 2,683,627 |
| 1861 ... | 54,869 | 1871 ... | 403,142 | 1881 ... | 2,620,626 |
| 1862 ... | 70,460 | 1872 ... | 402,000 | 1882 ... | 3,855,000† |
| 1863 ... | 70,720 | 1873 ... | 365,340 | 1883 .. | 3,627,750 |
| 1864 ... | 120,470 | 1874 .. | 10,821* | 1884 ... | 3,216,320 |
| 1865 ... | 102,360 | 1875 ... | 34,296* | 1885 ... | 3,311,419 |
| 1866 ... | 89,912 | 1876 ... | 432,418 | 1886 ... | 3,325,228 |
| 1867 ... | 136,073 | 1877 ... | 1,040,264 | 1887 ... | 4,400,000 |
| 1868 ... | 154,120 | 1878 ... | 1,305,656 | | |
| 1869 ... | 164,800 | 1879 ... | 1,282,671 | | |

Exports have been as under :—

| Year. | Tons. | Year. | Tons. |
|---|---|---|---|
| 1878 ... | 1,255,255 | 1883 ... | 3,426,661 |
| 1879 ... | 1,160,248 | 1884 ... | 3,193,919 |
| 1880 ... | 2,407,835 | 1885 ... | 3,330,550 |
| 1881 ... | 2,550,548 | 1886 ... | 3,180,787 |
| 1882 ... | 3,733,176† | 1887 ... | 4,188,696 |

It is probable that the maximum export has been reached, and that it will diminish as the smaller concessions become exhausted, until the exports are reduced to 1,500,000 tons wholly derived from those companies who have secured large reserves. The blast furnaces in the vicinity of Bilbao will require about 500,000 tons annually.

The probable results of the situation will be an augmentation of the price of ore, unless the new districts near the sea restore the balance between supply and demand. M. W. B.

* Carlist War. † Completion of the Improvements of the River Nervion.

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## THE MINES OF BILBAO.

*Les Mines de Somorrostro. By* M. G. GANDOLFI. *Revue Universelle des Mines, 1888, Série 3, Vol. 4, pp. 16-42, 126-154, 263-282, plates 2, 3, 6, 7.*

This memoir details the modes and cost of working ; means and cost of transport, wire-rope ways, inclined planes, endless chains and ropes ; railways and "drops." M. W. B.

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## GRISOUTITE, CARBONITE, DYNAMITE, &c.

*Des Expériences faites sur les nouveaux Explosifs et notamment sur la Grisoutite, en présence des poussières de Charbon et du Gaz. By* M. BRAIVE. *Revue Universelle des Mines, 1888, Série 3, Vol. 4, pp. 248-262.*

The excellent results obtained by the use of water cartridges suggested to Mr. E. Müller, of Cologne, the very ingenious idea of introducing water into the

explosive substance, not in a fluid form which could not be retained, but as a solid. Certain salts are combined with water, these combinations are perfectly definite, but the quantity varies with the salt as shown by the following table :—

| | | | |
|---|---|---|---|
| Carbonate of Soda ... ... ... | 63 per cent. of combined water. | | |
| Phosphate of Soda ... ... ... | | do. | do. |
| Sulphate of Soda ... ... ... | 56 | do. | do. |
| Phosphate of Magnesia ... ... | 51 | do. | do. |
| Sulphate of Magnesia ... ... ... | 51 | do. | do. |
| Sulphate of Alumina ... ... ... | 49 | do. | do. |
| Ammoniacal Alum ... ... ... | 48 | do. | do. |
| Borax ... .. ... ... ... | 47 | do. | do. |
| Potassium Alum ... ... ... | 45½ | do. | do. |
| Sulphate of Iron ... . ... | 45 | do. | do. |
| Chrome Alum ... ... ... ... | 43 | do. | do. |

The inventor incorporates one of these salts in a very divided state with a suitable explosive ; the new explosive is called grisoutite, in which the proportion of water can be varied by the salt or the mixture. Some of the salts are unsuitable on account of their action on nitro-glycerine, others part with their water too readily. and the most suitable salt is sulphate of magnesia, which is stable and cheap.

Experiments were recently made at Schebusch, near Cologne. A special apparatus was provided. A solid block of Krupp steel was sunk vertically in the ground, to be used like a mortar or cannon, and in it a hole was bored about 2 inches diameter. A sheet iron cylinder, 5 feet high and 4 feet diameter, was placed over the mortar and formed the experimental chamber.

The experiments were made with coal gas, 16 per cent. of which, with air, gave the most inflammable mixture. The coal dust used was obtained from very dangerous mines ; about 5 pounds of the finest dried dust only was used in each experiment. The coal dust was placed above and below the cartridge in the hole, and the remainder was sprinkled on sheets of paper placed on the top of the hole. All the shots were fired by electricity. Any required temperature was attained in the experimental cylinder.

The following are the details of the experiments :—

1. *Dynamite :* Composed of 75 per cent. of nitro-glycerine, and 25 per cent of infusorial earth. A cartridge of ·26 ounce, Camphausen coal dust, 8 per cent. of gas, temperature 62½ degs. Fahr. Violent explosion of the gas and coal dust, thick flames were thrown for some yards above the apparatus.

2. *Grisoutite :* A cartridge of ·53 ounce, Camphausen dust, 10 per cent. of gas, temperature, 71½ degs. Fahr No flame or explosion, black cloud of dust.

3. *Grisoutite :* A cartridge ·35 ounce, 10 per cent. of gas, temperature 71½ degs. Fahr., same dust. Neither flames nor explosion.

4. *Grisoutite :* A cartridge of ·28 ounce, 12 per cent. of gas, temperature 71½ degs. Fahr., same dust. Neither flames nor explosion.

5. *Grisoutite :* ·53 ounce, 12 per cent. of gas, temperature 80½ degs. Fahr. Neither flames nor explosion.

6. *Grisoutite :* ·53 ounce, 12 per cent. of gas, temperature 80½ degs. Fahr., very dangerous dust from Neu- Iserlohn Neither flames nor explosion.

7. *Grisoutite :* ·88 ounce, 12 per cent. of gas, temperature 71½ degs. Fahr., Neu-Iserlohn dust. Neither flames nor explosion.

8. *Grisoutite :* ·71 ounce, 16 per cent. of gas, temperature 68 degs. Fahr., same dust. Neither flames nor explosion.

9. *Favier Explosive* was used, but the cartridge was burst without explosion, owing to an inferior detonator.

10. *Carbonite:* ·71 ounce, 16 per cent. of gas, temperature 66 degs. Fahr., same dust. No explosion.

11. *Gelatine Dynamite:* ·28 ounce, with neither coal dust or gas. Flames visible.

12. *Grisoutite:* ·28 ounce, with neither coal dust or gas. No flames visible.

13. *Gelatine Dynamite:* ·28 ounce, 8 per cent. of gas, Neu- Iserlohn dust, temperature 57 degs. Fahr. No explosion, but flames were visible.

14. *Dynamite:* ·28 ounce, 10 per cent. of gas, temperature 68 degs. Fahr., Neu-Iserlohn dust. An exceedingly violent explosion, a thick column of flame was projected for many yards high, and as night had fallen, it lighted up the heath.

M. W. B.

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## THE RAMMELSBERG MINE (HARTZ).

*Sur le Rammelsberg (Bas- Harz). By* L. Babu. *Annales des Mines, Série 8, 1887, Vol. 12, pp. 335-343, Plate X.*

This mine is situated on the Rammelsberg mountain, and the deposit, whose thickness is sometimes 100 feet or more dips between 40 degs. and 55 degs. to the south-east, and into the mountain.

It is situated between Devonian schists, the floor being sterile, and the roof being more or less impregnated with pyritous matters. The ore is chiefly sulphide of copper, zinc, or galena and sulphate of baryta.

After describing the deposits and alluding to the opinions of other persons, the writer expresses his belief that the mineral body is a submarine deposit due to chemical precipitation, regularly interstratified, and is itself finely stratified parallel to the bedding of the surrounding schists. M. W. B.

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## IRON ORE MINING.

*The Chapin Iron-Mine, Lake Superior. By* Per Larsson. *Transactions of the American Institute of Mining Engineers, Vol. 16, 1887, pp. 119-128, 2 maps and 7 figures.*

The Chapin mine, on the Menominee Range, was opened in 1880, and has produced 1½ millions of tons of soft blue hematite, containing 63 per cent. of iron, and 07 of phosphorus. There are three ore bodies, the largest is 2,500 feet long, and 130 feet thick in middle, from which it narrows to the ends. Eastward of this is a second lens of ore of the same quality, which, in the sixth level, has a length of 550 feet, and a maximum width of 100 feet.

Further east the third ore-lens is found, which is about 100 feet long and 20 feet wide. The hanging wall consists of about 200 feet of clay slates, covered by a heavy belt of magnesian limestone, the foot wall is also a clay slate.

The first ore was mined by "stull stopping," in which heavy pillars of ore are left around the shafts, and large "rooms" are made in the ore by backstoping, after which rows of long heavy timbers are placed across the excavated rooms, covered by lagging to prevent pieces of ore from dropping upon the workmen.

Then the "modified Nevada system" was tried, the shafts were still kept in the ore, and protected by strong pillars, and the excavations made secure by a series of framed cubes of timber. After the shafts were connected by levels driven near the foot wall, rooms were laid out 18 feet apart, and the ore worked towards the hanging wall by breast stoping, and the ore worked upwards in lifts, each of which were strongly timbered. This part of the mine showed signs of crushing, although 50 per cent. of the ore was left, and the system was shortly abandoned.

A new system was then adopted, and the shafts sunk in the foot wall, and cross-cuts driven to the ore, and connected by drifts running about 20 feet from the ore deposit. If the ore is firm and under 20 feet wide, the full width is mined lengthwise on the deposit. As the stope advances, filled is trammed from a chute from the "rock winze" in small cars, and dumped near the breast of the stope. This filling is kept 5 feet below the roof, to allow the passage of the cars. Where the ore is more than 20 feet wide, the filling must be kept close to the back. Different men commence to work on the first stope, 50 feet from each other, in the ore drift run parallel to the main level, and make cuts about 8 feet high and 9 feet wide, right across the ore of the deposit, timber being used as required. These openings are then stowed with rock, the shovel being required to stow tight, other cuts are then made alongside and stowed as before, until the whole of the first stope is mined. Ore chutes and rock winzes must be prepared before the second stope is commenced. Raises to be used as ore chutes, and ladder ways are made from the side of the main level to the top of the second stope, and cross-cuts are driven into the ore. The chutes might be located in the ore, and connected with the main drifts by cross-cuts, but it is preferable to have them opening directly into the levels, especially if machine haulage is used. The ore chutes are about 50 feet apart, and the rock winzes about 100 feet apart sunk from the upper level. The first thing to be done in the second stope is to connect the rock winze with the cross-cut leading to the ore chute, after which the ore will be taken out and filling brought in, as described above. The third stope is prepared and mined in a similar way, and so on until the entire lift is mined. About four tons of filling are used per 10 tons of ore removed. M. W. B.

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## HAASE'S SYSTEM OF SINKING THROUGH QUICKSANDS.

*Schachtabteufen nach dem Verfahren von Haase. Zeitschrift für das Berg-Hütten und Salinen-wesen, Vol. XXXVI, 1888, pp. 225-226, and Plate 6.*

The seam of lignite, 23 feet thick, at the Guerini Colliery (Cottbus mining district), with a roof of 4 feet of bituminous clay, is covered with 87 feet of quicksand. In the pumping-engine shaft, the water was met with at a depth of 10 feet, and the sinking was stopped at 20 feet, owing to the large influx of water and sand.

The sinking was then resumed by Haase's system, by which a series of wrought-iron tubes are driven downwards, side by side, so as to form a lining to the intended shaft. The shaft was a rectangle 10·8 feet by 8·5 feet within the ordinary timbering, and reduced to 9·5 feet by 7·2 feet within the tubular lining. The single tubes are 13·1 feet long, with an internal diameter of 4·1 inches and ·2 inch thick. Wooden guides, with cast-iron cross bars at the top and bottom, were attached to the timbering of the shaft, so as to ensure the tubes being driven downwards in the required positions. The depth to the coal being 71 feet, four lengths

six sets of the tubes were used in the work, which commenced on May 24, 1887, and the tubes reached the clay above the coal on October 25, 1887. Sixty-four tubes were used, eighteen on each of the long sides, and fourteen on each of the short sides of the pit.

The work was completed in 225 working shifts of 12 hours each; the items of cost being as under:—

| Sets of Tubes. | Time occupied in Driving. | Wages, Including Two Enginemen. | Length of Tubes Inserted. | Cost per Foot of Tube Inserted. |
|---|---|---|---|---|
| No. | | £ s. d. | Feet. | s. d. |
| 1 | May 24 to June 8, 1887 | 21 12 6 | 688 | 0 7·54 |
| 2 | June 9 ,, ,, 22, ,, | 18 15 0 | 781 | 0 5·76 |
| 3 | ,, 23 ,, July 7, ,, | 18 6 6 | 794 | 0 5·54 |
| 4 | July 8 ,, August 13, ,, | 33 11 9 | 777 | 0 10·37 |
| 5 | August 14 ,, Sept. 18, ,, | 39 0 3 | 797 | 0 11·74 |
| 6 | Sept. 19 ,, October 25, ,, | 36 11 9 | 603 | 1 2·56 |
| | Total ... ... ... | 167 17 9 | 4,440 | 0 9·07 |
| | Two Officials ... ... ... ... | 53 17 3 | — | 0 2·91 |
| | Cost of 4,724 Feet of Tubes & Tools | 1,676 1 6 | — | 7 6·60 |
| | Coal for Boilers ... ... ... | 204 14 9 | — | 0 11·07 |
| | Total Cost... ... ... | 2,102 11 3 | 4,440 | 9 5·65 |

The removal of the sand and the preparation of the permanent iron tubbing of the shaft was then proceeded with; about 30 feet of the shaft were completed in November, 1887. The water was removed by two pulsometer pumps, at the rate of about 300 gallons per minute. M. W. B.

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## MINING IN LARGE BODIES OF ORE.

*By* Richard P. Rothwell. *Transactions of the American Institute of Mining Engineers, Vol. XVI, 1888, pp. 862-870, and 4 figures.*

Where the ore is hard enough to stand over the width of the vein, the following system may be used:—The ore is taken down in an overhand stope running the width of the vein for any length and for a height of say 12 feet. A timber drift is built along the floor of the stope, and the remainder of the stope is packed with waste sent from the surface through winzes previously sunk or upraised at intervals of 50 feet in the length of the stope A "mill" or chute is carried up every 50 feet along the level to run down the ore, and is made about 4 feet square inside, and built of hard wood. The filling is planked over close to the back of the stope to keep the ore from mixing with the filling.

It is suggested by the writer that it will be found more simple, economical, and advantageous to work the vein from the top downwards instead of upwards. All dead work to be avoided by making the drifts, cross-cuts, chutes, and winzes, where required in the solid ore. All the levels and stopes are timbered in undisturbed ore, and being only one "set" in width are easily held, and require but light timber, and much of this timber is drawn and saved in letting the roof down. When the stope comes up to the filling, this is only supported over one set of timber, while it rests on the solid ore on each side. The packing follows the ore down, and as long as this occurs, the cave on the surface is constantly filled from "borrowing" pits much cheaper than by sending the filling underground. If found desirable, the filling may be sent down as in other cases through chutes. This system renders it possible to obtain, practically, all the ore in the vein. The length of working faces is increased, and more ore can be extracted from a given area, as compared with any other system. M. W. B.

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## MODE OF DEPOSITION OF THE IRON ORES OF THE MENOMINEE RANGE, MICHIGAN.

*By* John Fulton. *Transactions of the American Institute of Mining Engineers, Vol. XVI, 1887, pp. 525-536, map and section and 6 figures.*

The Menominee Range is some 200 to 300 feet higher than the general level of the adjacent country, and forms a ridge, 27 miles in length, and the iron ore mines are situated on the southern flank.

Geologically, the range is composed of three distinct groups of Huronian rocks. The lower or "Norway limestone belt" consists of light-coloured limestone beds of a crystalline siliceous character. Above this is the Quinnesec ore formation, about 1,000 feet thick of siliceous or jasper slates impregnated with ferric oxide, succeeded by argillaceous hydro-mica and flesh-coloured slates, and contains the deposits of iron ore. Above this is the Lake Hanbury slate group, a series of dark gray, slaty or schistose beds with occasional quartzose bands, having a total thickness of 2,000 feet.

These three distinct groups of rocks forming the range, succeed each other conformably, dipping at high angles to the south in the portion of the range east of Quinnesec, and westward of this they dip to the north.

The iron ore appears to follow two or three planes of deposit, exhibiting wide differences in their relative distance from the limestone. The deposits usually consist of lenticular masses of ore (with irregular elliptical outlines) interstratified with the associated jaspers and clay slates. The writer describes the occurrence of the iron ore as contact deposits between the siliceous or jasper slates, and the aluminous or soapstone slates or limestone, or deposits in jasper slates. In some cases the iron ore is separated from the limestone by a brown sediment known as "soap rock." A number of pits exist filled with blue ore, which appears to have been carried by water from the original deposit.

These deposits of hematite are evidently original sediments, swelling at the middle and tapering at the edges, blending with the rock at their boundaries. It is considered that their original form was thinly bedded ferriferous carbonates, with admixtures of magnetite, which have been converted into hematite by heat and chemical action.

The following table exhibits the composition of these ores :—

| Mines. | Metallic Iron. | Insoluble Matter. | Phosphorus. |
|---|---|---|---|
| Vulcan ... ... ... ... ... | 58·75 | 9·00 | ·045 |
| Cyclops ... ... ... ... ... | 61·37 | 7·33 | ·015 |
| Norway ... ... ... ... ... | 53·27 | 13·02 | ·036 |
| Quinnesec ... ... ... ... | 64·56 | 7·69 | 037 |

The shipments from its opening in 1877 to the end of 1887 were 7,611,998 tons.

M. W. B.

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## EXTRACTION OF COPPER FROM PYRITES.

*Neues Kupferextractionsverfahren für Kupferkiese. By* Josef Perino. *Berg- und Hütten-männische Zeitung, Vol. XLVII, 1888, pp. 177-179.*

This new process depends upon the capacity of ferric nitrate for oxidising at low temperatures (122 degs. to 302 degs. Fahr.), the sulphide of copper in the ore into sulphate of copper.

The powdered pyrites is mixed with ferric nitrate, and exposed to a temperature of about 104 degs.; nitrous fumes are given off accompanied with the formation of sulphate of copper. Then the temperature is gradually increased to 212 degs., and 300 degs., producing, after washing with water, pure sulphate of copper, whilst the residue consists of unchanged sulphides of iron, sulphide of silver, and ferric oxide derived from the ferric nitrate.

The copper is reduced from its solution by metallic iron. The ferric nitrate is prepared from the solution of sulphate of iron, by treatment with a strong solution of nitrate of strontium or calcium, to form ferrous nitrate, which is converted to the ferric condition by the nitrous fumes of the original reaction.

M. W. B.

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## MINING SCHOOLS IN PRUSSIA.

*Die Bergschulen im Preussischen Staate. Zeitschrift für das Berg- Hütten und Salinen-wesen, Vol. XXXVI, pp. 1-61.*

Details are given of the mining schools at Bardenberg, Bochum, Clausthal, Dillenburg, Eisleben, Essen, Saarbruck, Siegen, Tarnowitz, Waldenburg, and Wetzlar. The average attendance of students varied from 864 to 991 per annum in recent years.

The subject is considered under the heads of: development of mining schools; general regulations; the existing schools; attendance of students; summary of the statutes and regulations and lists of text-books used. M. W. B.

## GERMAN MINERAL STATISTICS.

*Produktion der Bergwerke, Salinen, und Hütten im Deutschen Reichs-und Zollgebiet für das Jahr 1888. Glückauf, pp. 227-228. Essen, April, 1889.*

| Minerals. | Total Production in Tons. | | Total Production. Value in £ sterling. | | Average Value per Ton of 1,000 kilogs. | |
|---|---|---|---|---|---|---|
| | 1888. | 1887. | 1888. | 1887. | 1888. | 1887. |
| | | | £ | £ | £ s. d. | £ s. d. |
| Coal ... ... ... | 65,321,834 | 60,333,984 | 17,052.150 | 15,553,850 | 0 5 2⅔ | 0 5 2 |
| Brown Coal ... ... | 16,541,977 | 15,883,634 | 2,038,450 | 2,008,750 | 0 2 5½ | 0 2 6⅓ |
| Rock salt ... ... | 414.557 | 405,420 | 90,800 | 93,100 | 0 4 4½ | 0 4 7 |
| Kainite ... ... ... | 318,576 | 239,412 | 233,350 | 170,450 | 0 14 8 | 0 14 3 |
| Other potassium salts | 916,759 | 840,691 | 512,400 | 471,850 | 0 11 2 | 0 11 2¾ |
| Iron ores ... ... | 10,664,789 | 9 351,106 | 1,998.200 | 1 700,250 | 0 3 9 | 0 3 7½ |
| Zinc ores ... ... | 667,760 | 900,712 | 687,350 | 501,100 | 1 0 7 | 0 11 1½ |
| Lead ores ... ... | 161,775 | 157,570 | 831,750 | 796,150 | 5 2 10 | 5 1 0¾ |
| Copper ores ... ... | 530,864 | 507,587 | 875,650 | 727,600 | 1 13 0 | 1 8 8 |
| Silver and gold ores ... | 20,380 | 25,725 | 204,300 | 208,900 | 10 0 6 | 8 2 5 |
| Manganese ores ... | 28,704 | 38,385 | 33,400 | 51,150 | 1 3 3 | 1 6 8 |
| Table Salt ... ... | 493,400 | 480,962 | 532,400 | 571,200 | 1 1 7 | 1 3 9 |
| Potassium chloride ... | 142,441 | 128,208 | 910,850 | 858,350 | 6 7 10½ | 6 13 11 |
| Glauber's salt ... ... | 42,175 | 39,918 | 56,100 | 59,200 | 1 6 7½ | 1 9 8 |
| Raw iron (all kinds) ... | 4,258,471 | 3,954,413 | 9,346,950 | 8,131,250 | 2 3 11 | 2 1 1½ |
| Zinc ... ... ... | 133,224 | 130,493 | 2,178,800 | 1,829,850 | 16 7 1 | 14 0 5½ |
| Lead (pig lead) ... | 96,995 | 94,920 | 1,242,400 | 1 124,750 | 12 16 2 | 11 16 11¾ |
| Copper (copper ingots) | 20,872 | 20,202 | 1,524 800 | 886,100 | 73 1 1½ | 43 17 3 |
| | Kilogrammes | Kilogrammes | | | per kilog. | per kilog. |
| Silver ... ... ... | 406,567 | 367,633 | 2,571,250 | 2,407,900 | 6 6 6 | 6 11 0 |
| Gold ... ... ... | 1,810 | 2,251 | 252,650 | 314,050 | 139 11 1½ | 139 10 10 |
| | Tons. | Tons. | | | per ton. | per ton. |
| Sulphuric acid (all kinds) ... ... | 338,195 | 325,777 | 585,600 | 545,350 | 1 14 7½ | 1 13 5¾ |
| Cast iron (2nd smelting) | 779,904 | 706,557 | 6,381,000 | 5.671.150 | 8 3 7½ | 8 0 6½ |
| Refined iron and steel | 1,547,357 | 1,513,058 | 9,310,050 | 8,509,700 | 6 0 4 | 5 12 5¾ |
| Wrought iron and Bessemer steel ... | 1,785.354 | 1,688,809 | 10,918,950 | 9,944,850 | 6 2 3¾ | 5 17 9¼ |

In the above calculation of values, the German mark is taken as equal to one shilling. From the above table it may be gathered that in all mineral products there has been an increase in 1888 over 1887, with the exception of zinc ores and gold which show a decrease. Prices too seem to have been generally higher in 1888 than in the previous year, but the above statistics are not quite complete, there being still some works whose annual report for 1888 has not yet come to hand.

In the following table will be found the coal, lignite, and iron ore production of the separate states and mining districts of the Empire. As before, the mark of 100 pfennige is reckoned equal to one shilling :—

| | Production in 1888. | | Production in 1887. | |
|---|---|---|---|---|
| | Tons of 1,000 kilos. | Values in £ sterling. | Tons of 1,000 kilos. | Values in £ sterling. |
| 1. Coal. | | £ s. d. | | £ s. d. |
| I. Kingdom of Prussia. Mining Inspection District of Breslau ... ... | 17,642.284 | 3,650,577 8 0 | 16,187,078 | 3,387,662 0 0 |
| I. Kingdom of Prussia. Mining Inspection District of Halle... ... ... | 22,594 | 12,052 1 0 | 24.884 | 11,770 0 0 |
| I. Kingdom of Prussia. Mining Inspection District of Clausthal ... ... | 497.295 | 170.972 4 0 | 470.043 | 160,228 0 0 |
| I. Kingdom of Prussia. Mining Inspection District of Dortmund ... ... | 33.223,614 | 7.972,924 17 0 | 30,150.238 | 7,001,881 2 0 |
| I. Kingdom of Prussia. Mining Inspection District of Bonn ... ... ... | 8,086,713 | 2.789,398 1 0 | 7,716,040 | 2,633,888 16 0 |
| Total for the Kingdom of Prussia | 59,472,500 | 14,595,924 11 0 | 54,548,283 | 13,195,429 18 0 |
| II. Bavaria ... ... ... ... ... | 732.597 | 323,510 13 0 | 683,619 | 299.656 7 0 |
| III. Saxony ... ... ... ... ... | 4,297,649 | 1,825.637 9 0 | 4.293.417 | 1,760,796 19 0 |
| IV. Alsace Lorraine ... ... ... | 689,135 | 256,897 8 0 | 693,679 | 254,243 18 0 |
| V. Other German States... ... ... | 129,953 | 50.157 16 0 | 114,986 | 43,738 8 0 |
| Total for the German Empire ... | 65,321,834 | 17,052,127 17 0 | 60.333,984 | 15,553,865 10 0 |
| 2. Lignite. | | | | |
| I. Prussia. Mining Inspection District of Breslau ... ... | 454,802 | 77.263 16 0 | 391,184 | 70,240 10 0 |
| I. Prussia. Mining Inspection District of Halle... ... ... | 12,077,770 | 1.451,795 4 0 | 11,648,527 | 1,449,306 13 0 |
| I. Prussia. Mining Inspection District of Clausthal ... ... | 203,739 | 35.990 1 0 | 202 155 | 35,590 10 0 |
| I. Prussia. Mining Inspection District of Bonn... ... ... | 503,645 | 41,561 1 0 | 454,621 | 38,473 0 0 |
| Total for the Kingdom of Prussia | 13,239.956 | 1,606.610 2 0 | 12,696,487 | 1.593,610 13 0 |
| II. Bavaria ... ... ... ... ... | 5,759 | 1,101 17 0 | 6,261 | 1,592 14 0 |
| III. Saxony ... ... ... ... ... | 823,313 | 119,717 7 0 | 766,732 | 111,844 7 0 |
| 3. Iron Ores. | | | | |
| I. Kingdom of Prussia. Mining Inspection District of Breslau ... ... | 700,736 | 136,268 12 0 | 650.731 | 127,509 2 0 |
| I. Kingdom of Prussia. Mining Inspection District of Halle... ... ... | 47,450 | 9,873 11 0 | 35,394 | 7,370 12 0 |
| I. Kingdom of Prussia. Mining Inspection District of Clausthal ... ... | 363.839 | 30,421 18 0 | 348,874 | 30,120 9 0 |
| I. Kingdom of Prussia. Mining Inspection District of Dortmund ... ... | 561,974 | 120,525 4 0 | 611,201 | 125,764 15 0 |
| I. Kingdom of Prussia. Mining Inspection District of Bonn ... ... ... | 2,470,957 | 979,840 6 0 | 2,187,564 | 798.605 17 0 |
| Total for the Kingdom of Prussia | 4,144,956 | 1,276,929 11 0 | 3,833,764 | 1,089,370 15 0 |
| II. Bavaria ... ... ... ... | 119,254 | 25,001 2 0 | 96,910 | 20,803 19 0 |
| III. Saxony ... ... ... ... | 12,166 | 6,224 13 0 | 11,706 | 6,124 19 0 |
| IV. Hesse ... ... ... ... ... | 118.362 | 38,296 14 0 | 103,746 | 34,692 8 0 |
| V. Brunswick ... ... ... ... | 130,676 | 16,858 7 0 | 132,926 | 15,924 2 0 |
| VI. Waldeck ... ... ... ... | 37,168 | 8,187 9 0 | 23,187 | 4,425 7 0 |
| VII. Alsace Lorraine ... ... ... | 2,805 264 | 300,124 7 0 | 2,471,197 | 255,438 10 0 |
| VIII. Other German States ... ... | 35,017 | 7,678 11 0 | 27,959 | 6.432 11 0 |
| Total for the German Empire ... | 7,402,863 | 1,679.300 14 0 | 6,701.395 | 1,433.212 11 0 |
| Duchy of Luxemburg ... ... | 3,261.926 | 318,899 3 0 | 2,649.711 | 267 051 1 0 |
| German Empire and Luxemburg | 10,664 789 | 1,998,199 17 0 | 9,351,106 | 1 700,263 12 0 |

L. L. B.

## ON THE MOISTURE OF THE AIR OF MINES.

*Ueber den Feuchtigkeitsgehalt der Grubenwetter.* *By* R. Nasse. *Zeitschrift für das Bery- Hütten und Salinen-wesen. Vol. XXXVI. 1888, pp 179-186.*

This paper is supplemented by a table of experiments at thirteen of the principal Westphalian collieries, showing the relative humidity of the air in various parts of the mine.

M. W. B

# THE TRANSMISSION OF POWER BY ELECTRICITY.

*By* FRANK J. SPRAGUE. *Journal of the Franklin Institute. Vol. CXXVII., 1889, pp. 161-176, 254-264. 3 Plates.*

PER HORSE-POWER DELIVERED BY MOTOR.

| Distance in Feet. | E.M.F. at terminals of Motor. | Commercial Efficiency. | Horse-power required at Dynamo. | Weight in Pounds. | | | | Costs. | | | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Dynamo. | | Motor. | | Uncovered Wire. | Water-power. | Dynamo, etc. | Uncovered Wire, etc. | Motor, etc. | Total Cost of Electrical Equipment. | |
| | | | | Gross. | Nett. | Gross. | Nett. | | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | |
| 5,000 | 400 | 65 | 1·53 | 168 | 153 | 130 | 97 | 68·88 | 6 2 6 | 12 4 9 | 3 9 0 | 9 0 0 | 24 13 9 | Copper at 1s. |
| 10,000 | ,, | 54 | 1·85 | 204 | 185 | ,, | ,, | 144·32 | 7 8 0 | 14 16 0 | 7 4 3 | ,, | 31 0 3 | Dynamos at £8. |
| 15,000 | ,, | 47 | 2·13 | 234 | 213 | ,, | ,, | 210·88 | 8 10 6 | 17 0 9 | 10 11 0 | ,, | 36 11 9 | Motors at £9. |
| 5,000 | 800 | 71 | 1·41 | 155 | 141 | ,, | ,, | 39·68 | 5 12 9 | 11 19 9 | 1 19 9 | 9 10 0 | 23 9 6 | Copper at 1s. |
| 10,000 | ,, | 65 | 1·53 | 168 | 153 | ,, | ,, | 71·72 | 6 2 6 | 13 0 0 | 3 11 9 | ,, | 26 1 9 | |
| 15,000 | ,, | 59 | 1·69 | 183 | 169 | ,, | ,, | 110·92 | 6 15 3 | 14 7 3 | 5 11 0 | ,, | 29 8 3 | Dynamos at £8 10s. |
| 20,000 | ,, | 54 | 1·85 | 204 | 185 | ,, | ,, | 150·32 | 7 8 9 | 15 14 6 | 7 10 3 | ,, | 32 14 9 | |
| 25,000 | ,, | 50 | 2·00 | 220 | 200 | ,, | ,, | 187·52 | 8 0 0 | 17 0 0 | 9 7 6 | ,, | 35 17 6 | |
| 30,000 | ,, | 47 | 2·13 | 234 | 213 | ,, | ,, | 219·68 | 8 10 6 | 18 2 0 | 10 19 9 | ,, | 38 11 9 | |
| 35,000 | ,, | 45 | 2·22 | 244 | 222 | ,, | ,, | 242·80 | 8 17 9 | 18 17 6 | 12 2 9 | ,, | 40 10 3 | Motors at £9 10s. |
| 10,000 | 1,200 | 69 | 1·45 | 160 | 145 | ,, | ,, | 51·84 | 5 16 0 | 13 1 0 | 2 11 9 | 10 0 0 | 25 12 9 | |
| 15,000 | ,, | 65 | 1·53 | 168 | 153 | ,, | ,, | 74·60 | 6 2 6 | 13 15 6 | 3 14 6 | ,, | 27 10 0 | Copper at 1s. |
| 20,000 | ,, | 61 | 1·64 | 180 | 164 | ,, | ,, | 101·28 | 6 11 3 | 14 15 3 | 6 1 3 | ,, | 29 16 6 | |
| 25,000 | ,, | 57 | 1·75 | 193 | 175 | ,, | ,, | 130·80 | 7 0 0 | 15 15 0 | 6 10 9 | ,, | 32 5 9 | |
| 30,000 | ,, | 54 | 1·85 | 204 | 185 | ,, | ,, | 156·32 | 7 8 0 | 16 13 0 | 7 16 3 | ,, | 34 9 3 | Dynamos at £9. |
| 35,000 | ,, | 51 | 1·96 | 216 | 196 | ,, | ,, | 184·72 | 7 16 9 | 17 12 9 | 9 4 9 | ,, | 36 17 6 | |
| 40,000 | ,, | 49 | 2·04 | 224 | 204 | ,, | ,, | 205·52 | 8 3 3 | 18 7 3 | 10 5 6 | ,, | 38 12 9 | |
| 45,000 | ,, | 47 | 2·13 | 234 | 213 | ,, | ,, | 288·44 | 8 10 6 | 19 3 6 | 11 8 6 | ,, | 40 12 0 | Motors at £10. |
| 50,000 | ,, | 45 | 2·22 | 244 | 222 | ,, | ,, | 252·52 | 8 17 9 | 19 19 6 | 12 12 6 | ,, | 42 12 0 | |

M. W. B.

## ON THE DISTRIBUTION OF THE INTERNAL FRICTION OF ENGINES.

*By* Robert H. Thurston. *Journal of the Franklin Institute, Vol. CXXVI., 1888, pp. 370-398.*

The following table contains the summary of the results :—

| Parts of Engine. | Description of Engine. | | | | |
|---|---|---|---|---|---|
| | Straight Line. | | Traction 7 in. × 10 in Locomotive Valve Gear. | Automatic 12in. × 18in Balanced Valve. | Condensing 21in. × 20in Balanced Valve. |
| | 6 in. × 12 in Balanced Valve. | 6 in. × 12 in Unbalanced Valve. | | | |
| | Rated Horse-Power of Engines. | | | | |
| | 20 | 20 | 20 | 100 | 113·88 |
| | Friction in Horse-Power. | | | | |
| Main bearings | ·849 | ·849 | ·680 | 3·70 | 3·30 |
| Piston and rod | ·593 | ·593 | ·400 | 4·35 | 1·48 |
| Crank-pin | ·123 | ·123 | ·255 | | |
| Crosshead and wrist-pin | ·098 | ·098 | | | |
| Valve and rod | ·046 | ·631 | ·410 | ·83 | 1·47 |
| Eccentric strap | ·095 | ·095 | | | |
| Link and eccentric | — | — | ·165 | — | — |
| Air-pump | — | — | — | — | ·88 |
| Total | 1·804 | 2·389 | 1·910 | 8·88 | 7·13 |
| | Percentage of Rated Horse-Power. | | | | |
| Main bearings | 4·2 | 4·2 | 3·4 | 3·70 | 2·9 |
| Piston and rod | 3·0 | 3·0 | 2·0 | 4·35 | 1·3 |
| Crank-pin | ·6 | ·6 | 1·3 | | |
| Crosshead and wrist-pin | ·5 | ·5 | | | |
| Valve and rod | ·2 | 3·2 | 2·0 | ·83 | 1·3 |
| Eccentric strap | ·5 | ·5 | | | |
| Link and eccentric | — | — | ·8 | — | — |
| Air-pump | — | — | — | — | ·7 |
| Total | 9·0 | 12·0 | 9·5 | 8·88 | 6·2 |
| | Percentage of Total Friction. | | | | |
| Main bearings | 47·1 | 35·4 | 35·7 | 41·6 | 46·3 |
| Piston and rod | 32·9 | 25·0 | 20·9 | 49 1 | 20 7 |
| Crank-pin | 6·8 | 5·1 | 13·3 | | |
| Crosshead and wrist-pin | 5·4 | 4·1 | | | |
| Valve and rod | 2·5 | 26·4 | 21·5 | 9 3 | 20·6 |
| Eccentric strap | 5·3 | 4·0 | | | |
| Link and eccentric | — | — | 8·6 | — | — |
| Air-pump | — | — | — | — | 12 4 |
| Total | 100·0 | 100·0 | 100·0 | 100·0 | 100·0 |
| Weight on main bearing in pounds | 1,500 | 1,500 | 500 | 2,600 | 4,000 |
| Diameter of main bearing in inches | 3 | 3 | 2¼ | 5 | 5½ |
| Co-efficient of friction, engine light | ·10 | ·10 | ·31 | ·19 | ·09 |
| Co-efficient of friction, engine loaded | ·06 | ·06 | ·08 | ·05 | ·09 |
| Revolutions of main bearings per minute | 230 | 230 | 200 | 190 | 206 |

M. W. B.

## MINING PRODUCE OF THE DISTRICT OF DORTMUND (HANOVER, WESTPHALIA, AND RHENISH PRUSSIA) IN 1888.

*Productions-Übersicht der im Oberbergamtsbezirk Dortmund im Jahre 1888, in Betrieb gewesenen Bergwerke und Salinen. Glückauf, No. 24, 1889.*

### A.—COAL MINES.

| District | No. of Collieries. | Produce in Tons. | Persons Employed. |
|---|---|---|---|
| 1. Osnabrück ... ... ... ... | 5 | 130,371 | 927 |
| 2. Dortmund, North ... ... ... | 6 | 1,144,232 | 3,890 |
| 3. Do. East ... ... ... | 13 | 2,057,613 | 7,240 |
| 4. Do. West ... ... ... | 13 | 2,334,922 | 7,836 |
| 5. Witten .. ... ... ... | 9 | 1,692,273 | 5,852 |
| 6. Sprockhövel ... ... ... ... | 21 | 517,371 | 2,161 |
| 7. Dahlhausen ... ... ... ... | 14 | 2,056,202 | 7,445 |
| 8. Bochum ... ... ... ... | 12 | 3,079,113 | 9,712 |
| 9. Herne ... ... .. ... ... | 7 | 2,548,094 | 7,650 |
| 10. Recklinghausen ... ... ... | 10 | 2,679,972 | 7,989 |
| 11. Gelsenkirchen ... ... ... | 9 | 3,788,170 | 12,006 |
| 12. Essen ... ... ... ... ... | 8 | 3,344,129 | 8,948 |
| 13. Frohnhausen ... ... ... ... | 11 | 2,672,207 | 7,492 |
| 14. Oberhausen ... ... ... ... | 15 | 3,491,528 | 10,646 |
| 15. Altendorf ... ... ... ... | 13 | 1,082,768 | 3,184 |
| 16. Werden ... ... ... ... | 8 | 406,313 | 1,325 |
| Private Mines ... ... | 174 | 33,025,278 | 104,303 |
| Government Mines ... | 2 | 198,336 | 1,125 |
| Total of 1888 ... | 176 | 33,223,614 | 105,428 |
| Do. 1887 ... | 178 | 30,150,238 | 99,534 |

### B.—IRON ORE MINES.

| District. | No. of Mines. | Produce in Tons. | Persons Employed. |
|---|---|---|---|
| 1. Osnabrück ... ... ... ... | 12 | 247,060 | 1,188 |
| 2. Dortmund, North ... ... ... | 1 | 112,537 | 328 |
| 3. Do. East ... ... ... | 3 | 35,895 | 197 |
| 5. Witten .. ... ... ... ... | 2 | 170 | 10 |
| 6. Sprockhövel ... ... ... ... | 3 | 44,386 | 216 |
| 7. Dahlhausen ... ... ... ... | 1 | 118,457 | 533 |
| 16. Werden ... ... ... ... | 1 | 3,469 | 19 |
| Total of 1888 ... | 23 | 561,974 | 2,491 |
| Do. 1887 ... | 22 | 611,201 | 2,382 |

### C.—ZINC ORE MINES.

| District. | No. of Mines. | Produce in Tons. | Persons Employed. |
|---|---|---|---|
| 5. Witten... ... .. ... ... | 1 | 21,310 | 480 |
| 6. Sprockhövel ... .. ... ... | 2 | 190 | 4 |
| 16. Werden ... ... ... ... | 4 | 11,421 | 583 |
| Total of 1888 ... | 7 | 32,921 | 1,067 |
| Do. 1887 ... | 5 | 35,813 | 1,002 |

D.—LEAD ORE MINES.

| District. | No. of Mines. | Produce in Tons. | Persons Employed. |
|---|---|---|---|
| 5. Witten... ... ... ... ... | 2 | 164 | 21 |
| 16. Werden ... ... ... ... | 4 | 1,021 | 164 |
| Total of 1888 ... | 6 | 1,185 | 185 |
| Do. 1887 ... | 5 | 1,317 | 169 |

E.—COPPERAS MINES.

| District. | No. of Mines. | Produce in Tons. | Persons Employed. |
|---|---|---|---|
| 1. Osnabrück ... ... ... ... | 1 | 387 | 4 |
| 4. Dortmund, West ... ... ... | 3 | 730 | 4 |
| 6. Sprockhövel ... ... ... ... | 1 | 6,145 | 31 |
| 16. Werden ... ... ... ... | 1 | 32 | 1 |
| Total of 1888 ... | 6 | 7,294 | 40 |
| Do. 1887 ... | 6 | 9.833 | 51 |

F.—SALT WORKS.

| District. | No. of Works. | Produce in Tons | Persons Employed. |
|---|---|---|---|
| 1. Osnabrück ... ... ... ... | 2 | 1,212 | 29 |
| 2. Dortmund, North ... ... ... | 3 | 18,980 | 193 |
| Private Works ... .. ... | 5 | 20,192 | 222 |
| Government Works ... ... | 1 | 1,626 | 23 |
| Total of 1888 ... | 6 | 21,818 | 245 |
| Do. 1887 ... | 6 | 22,461 | 270 |

M. W. B.

## EXPERIMENTS UPON THE BOTY SAFETY LAMP.

*Bericht des* Dr. Schondorff *über Durschlag-Versuche mit Elektrischer Zündung* [*Die Lampen-Unter-Commission*]. *Anlagen zum Haupt-Berichte der Preussischen Schlag-Wetter-Commission, Vol. III., pp.* 142-152.

The experiments were made in the following manner :—

Ordinary lighting gas or fire-damp (from the Bonifacius Colliery, near Bochum) was mixed with air in a receiver, near to the explosion box. The ignition was made by an induction spark of ·04 inch; a bar, containing the two insulated wires, traversed the bottom of the lamp, and enabled the spark to be produced at any required height in the lamp.

The Boty lamp was used in the experiments, whose elements were varied by the use of glass cylinders of different widths and heights, and with gauzes varying in height, width, thickness of wire, and dimensions of mesh. A chimney, a diaphragm, and one or more gauzes could be used.

For each variation in the construction of the lamp and of the height of the point of ignition, experiments were made to find the limits of the composition of the gaseous mixture whose ignition would cause the flame to traverse the gauze of the lamp.

Dr. Schondorff considers that the following conclusions may be deduced.

The experiments show that as the point of ignition is raised in the axis of the lamp, a *height limit* is reached, beyond which the flame is not driven through the gauze, irrespective of the composition of the explosive mixture. This height limit is a measure of the safety of the lamp, and a lamp is so much the safer, according as the height limit is small.

When ignition is made at the height limit, the flame only traverses the gauze in the case of the most explosive mixtures, containing 14½ per cent. of lighting gas, or 9½ per cent. of fire-damp. As the point of ignition is lowered, the passage of the flame is made with less explosive mixtures. There is consequently an interval between the two percentage limits, between which there is a passage of the flame through the gauze. This measure of safety should be made when the point of ignition is ·4 inch above the wick tube. The *propagation of explosion interval* is measured in quarters of 1 per cent., and a lamp is so much safer according as this interval is small.

The flame was never driven through the gauze in experiments with fire-damp, even when the cap was only 2 inches high, consequently in all experiments made with fire-damp the gauze cone is removed and replaced by a plain disc of gauze closing the upper part of the lamp.

I.—EXPERIMENTS SHOWING THE EFFECT OF VARYING THE HEIGHT OF THE GLASS CYLINDER, WHOSE DIAMETER IS 2 INCHES.

| Wire Gauze. | | | | Height limit of the point of ignition, for glass cylinders whose heights are : | | | | Propagation of explosion intervals, for glass cylinders whose heights are : | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Diameter of wire. | Meshes per square inch. | Quotient of Safety. | 4·4 inches. | 3·6 inches. | 2 8 inches. | 2·0 inches. | 4·4 inches | 3 6 inches | 2·8 inches | 2·0 inches |
| | With Lighting gas, gauze 4 inches high. | | | | | | | | | | |
| | inches. | | | inches. | inches. | inches. | inches. | | | | |
| 1 | ·0185 | 574 | 7·50 | 3·6, 3·2 | 2·4 | 2·0 | ·4 | 26, 24 | 22, 18 | 12 | 0 |
| 2 | ·0177 | 574 | 7·02 | 4·0 | 3·2 | 2 4 | ·8 | — | — | — | — |
| 4 | ·0142 | 684 | 6·10 | 4·4 | 3·6 | 2·8 | 1·6 | — | — | — | — |
| 8 | ·0149 | 871 | 9·18 | — | 2·0 | ·4 | — | 18 | 10 | 0 | -- |
| 9 | ·0142 | 897 | 8·69 | 2·8 | 2·4 | 1·6 | ·4 | — | — | — | — |
| 10 | ·0154 | 916 | 10·45 | 1 6 | ·4 | — | — | — | — | — | — |
| 11 | ·0126 | 916 | 7·36 | 4·0, 3·6 | 3·2 | 2·4, 1·6, 1·2 | 1·2, ·8, ·4 | 28 | 18 | 14 | 4 |
| 12 | ·0110 | 968 | 6·39 | 4·8 | 4·0 | 4·0 | 2·0 | — | — | — | — |
| 13 | ·0071 | 968 | 3·45 | 6·4 | 5·6 | 4·8 | 4·0 | — | — | — | — |
| | With fire-damp, gauze 0 inches high (plain disc). | | | | | | | | | | |
| 14 | ·0079 | 874 | 3·53 | 2·8 | — | 1·4 | — | 14 | — | 11 | — |
| 15 | ·0087 | 832 | 4·00 | 3·0 | — | 1·4 | — | 14 | — | 10 | - |
| 16 | ·0114 | 852 | 5·75 | 2·4 | — | 1·2 | — | 11 | — | 10 | — |
| 17 | ·0146 | 906 | 9·27 | 2·0 | — | ·4 | — | 7 | — | 0 | — |
| 18 | ·0130 | 584 | 4·36 | 3·0, 3·2 | 2·2 | 1·4 | ·6 | 14, 13 | 14 | 11 | 4, 5 |
| 19 | ·0130 | 690 | 5·37 | 2·8 | — | — | ·4 | 14 | — | — | 0 |
| 20 | ·0130 | 858 | 7·25 | 2·4 | — | 1·0 | — | ·12 | — | 5, 3 | — |
| 21 | ·0130 | 997 | 8·78 | 2·0 | 1·4 | — | — | 10 | 7 | — | — |
| 22 | ·0130 | 1136 | 10·28 | 2·0 | 1·4 | — | — | 9 | 8 | — | — |
| 23 | ·0110 | 1446 | 10·80 | ·4 | — | — | — | 0 | — | — | — |

It appears, therefore, that the higher the glass cylinder the greater is the height limit and the propagation of explosion interval, and the less the safety of the lamp.

II.—EXPERIMENTS SHOWING THE INFLUENCE OF THE WIDTH OF THE GLASS CYLINDER, WHOSE HEIGHT IS 2·8 INCHES.

| Wire Gauze. | | | | Height limit of the point of ignition for glass cylinders whose diameters are: | | | | Propagation of explosion intervals for glass cylinders whose diameters are: | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Diameter of Wire. | Meshes per square inch. | Quotient of Safety. | 1·6 inches. | 2·0 inches. | 2·4 inches. | 2·8 inches. | 1·6 inches. | 2·0 inches. | 2·4 inches. | 2·8 inches. |
| | | | | With lighting gas, gauze 4 inches high | | | | | | | |
| | inches. | | | inches. | inches. | inches. | inches. | | | | |
| 11 | ·0126 | 916 | 7·36 | 1·6 | 2·4 | 2·0 | 2·4 | 10 | 14 | 10, 12 | 14, 8 |
| 11 | ·0126 | 916 | 7·36 | 2·0 | 2·4 | 2·8 | 2·4 | 14 | 16 | 6, 12 | 10, 12 |
| | | | | With fire-damp, gauze 0 inches high (plain disc). | | | | | | | |
| 14 | ·0079 | 874 | 3·53 | 1·6 | 1·4 | 1·2 | ·8 | 13 | 11 | 9 | 6 |
| 15 | ·0087 | 832 | 4·00 | 1·4 | 1·4 | 1·2 | 1·0 | 10 | 10 | 6 | 4 |
| 16 | ·0114 | 852 | 5·75 | 1·4 | 1·2 | ·6 | ·4 | 11 | 10 | 5 | 0 |
| 17 | ·0146 | 906 | 9·27 | 1·0 | ·4 | — | — | 2 | 0 | — | — |
| 18 | ·0130 | 584 | 4·36 | 1·8 | 1·4 | 1·2 | 1·2 | 12 | 11 | 9 | 7 |

It appears that in the experiments with lighting gas, the difference in the diameters of the glass has no influence. In the case of fire-damp, it appears that the explosion passes more easily through the gauze when the glass cylinder is narrowed, but it must be noted that in these experiments the gauze is represented by a simple disc.

III.—EXPERIMENTS SHOWING THE INFLUENCE OF THE HEIGHT AND SURFACE OF THE GAUZE, WHOSE WIRES ARE ·0126 INCH DIAMETER AND 916 MESHES PER SQUARE INCH WITH A GLASS CYLINDER 2·0 INCHES IN DIAMETER.

| Gauze Cap. | | | Height limit of the point of ignition for glass cylinders whose heights are: | | | | Propagation of explosion intervals for glass cylinders whose heights are: | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | Height. | Surface. | 4·4 inches. | 3·6 inches. | 2·8 inches. | 2·0 inches. | 4·4 inches. | 3·6 inches. | 2·8 inches. | 2·0 inches. |
| | | | With lighting gas. | | | | | | | |
| | inches. | sq. inches. | inches. | inches. | inches. | inches. | | | | |
| 11 | 2·0 | 1·07 | 4·0 | 3·2 | 2·4 | 1·6 | 32 | 26 | 20 | 14 |
| 11 | 4·0 | 2·17 | 4·0 | 3·2 | 2·4 | 1·2 | 24 | 18 | 14 | 4 |
| 11 | 6·0 | 3·27 | 3·6 | 2·4 | 1·6 | ·4 | 16 | 12 | 10 | 0 |

These experiments show that the safety of a lamp increases with the height and with the surface of the gauze.

IV.—EXPERIMENTS SHOWING THE INFLUENCE OF THE WIRE GAUZE; THE GLASS CYLINDER BEING 2 INCHES WIDE

With lighting gas, gauze 4 inches high.
With fire-damp, gauze 0 inches high.
[See table I].

In every instance the flame passed through No. 13 gauze, even when the point of ignition was placed in the middle of the gauze cap. With No 12 gauze the height limit extended above the top of the glass; but with the other gauzes the height limit fell within the glass. With the same mesh, the safety increased with the thickness of the wire, and with the same wire the safety increased with the number of mesh.

The degree of safety of different gauzes of the same metal can be represented by the equation—

$$Q = \frac{\cdot 4 \times D\ M}{1 - D\sqrt{M}},$$

D being the diameter of the wire in inches, and M the number of meshes per square inch.

This value (Q) is termed the quotient of safety. The open surface (F) of a square inch of gauze being represented by

$$F = (1 - D\sqrt{M})^2,$$

the preceding equation becomes

$$Q = \frac{\cdot 4\ D\ M}{\sqrt{F}}.$$

This equation shows the relation between D and M, for any desired quotient of safety Q. M. W. B.

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## THE FRÖHLICH ROCK-BORING MACHINE.

*Die machinelle Gesteinbohrung mit Fröhlich'schen Bohrmaschinen. By* H. Klüpfel. *Zeitschrift des Vereines Deutscher Ingenieure, Vol. XXXII, 1888, pp. 837-841, and 10 Figures.*

The Fröhlich rock borer has been used for some time at the Mansfeld mines to drive a drift 8·2 feet wide by 7·5 feet high in strong conglomerates, red sandstones, marls, &c. The results of continuous working since June 1885 to March 1888 are: 752½ working days of 24 working hours, no work being performed on Sundays or holidays; total length driven being 10,355 feet, equal to 13·7 feet per working day of 24 hours. M. W. B.

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## EXPERIMENTS UPON VARIOUS FORMS OF SAFETY LAMPS, AND IMPERFECT SAFETY LAMPS.

*Bericht des* Dr. Schondorff *über Untersuchung verschiedener Lampen-formen und beschädigter Lampen.* [*Die Lampen-Unter-Commission*]. *Anlagen zum Haupt-Berichte der Preussischen Schlagwetter-Commission. Vol. III., pp. 152-165.*

These experiments were made with mixtures of lighting gas, as it was found to be much more dangerous than fire-damp.

I.—THE DAVY LAMP, WITH CONICAL GAUZE; LOWER DIAMETER, 2·0 INCHES, AND UPPER DIAMETER, 1·6 INCHES.

| Wire Gauze. | | | | Propagation of Explosion Intervals, for Gauzes whose heights are | |
|---|---|---|---|---|---|
| No. | Diameter of Wire. | Meshes per Square Inch. | Quotient of Safety. | 2 Inches. | 4 Inches. |
| | Inches. | | | | |
| 14 | ·0079 | 874 | 3·53 | 20 | 28 |
| 15 | ·0087 | 832 | 4·00 | 22 | 20 |
| 18 | ·0130 | 584 | 4·36 | 20 | 24 |
| 19 | ·0130 | 690 | 5·37 | 14 | 8 |
| 20 | ·0130 | 858 | 7·25 | 0 | 0 |

The Davy lamp is, therefore, much less safe than a Boty lamp in a still atmosphere.

II.—CLANNY LAMP, WITH CYLINDRICAL GAUZE AND CAP.

These experiments showed that a cylindrical gauze was less safe than a conical one; and that the use of a cap doubling on the top of the gauze rendered it less safe; but it became more safe by doubling the lower portion of the gauze, though this closing should not be equivalent to a lengthening of the cylindrical glass.

III.—EXPERIMENTS WITH DIRTY GAUZE.

A Boty lamp was taken, with a cylindrical glass 2·8 inches high and 2 inches wide. A conical gauze was used, 4 inches high, with a surface of about 21·7 square inches.

| Wire Gauze, No. 9. Wire ·0142 inches diameter, 897 meshes per square inch, and Quotient of Safety, 8·69. | | Propagation of Explosion Intervals. |
|---|---|---|
| Clean. | Dirty. | |
| Square Inches. | Square Inches. | |
| 21·7 | — | 10 |
| 15·2 | 6·5 upper | 24 |
| 14·7 | 7·0 lower | 32 |

It will be seen that the safety of a lamp is decreased by the use of a dirty gauze, and more especially when the lower portion is dirty.

IV.—LAMPS WITH SEVERAL GAUZES (MARSAUT LAMP).

The outer one (*a*) was conical, 4 inches high and 2 inches wide at the bottom, and 1·4 inches wide at the top. The inner one (*b*) was also conical, 3·2 inches high, 1·6 inches wide at the bottom, and ·8 inch wide at the top. The third one (*c*

was a flat disc, placed across the top of the glass cylinder, 2·8 inches high and 2 inches wide.

| Wire Gauze. | | | | Propagation of Explosion Intervals, for combinations of Gauzes as under :— | | | |
|---|---|---|---|---|---|---|---|
| No. | Diameter of Wire. | Meshes per Square Inch. | Quotient of Safety. | *a* | *a* and *c*. | *a* and *b*. | *a*, *b*, and *c*. |
| | Inches. | | | | | | |
| 14 | ·0079 | 874 | 3·53 | 42 | 38 | 26 | 28 |
| 18 | ·0130 | 584 | 4·36 | 36 | 34 | 30 | 28 |
| 20 | ·0130 | 858 | 7·25 | 20 | 20 | 12 | 0 |
| 23 | ·0110 | 1,446 | 10·80 | 0 | — | — | — |

The use of several gauzes renders the lamp more safe ; it will be noted that the combinations *a* and *b* are more safe than *a* and *c*, showing that the surface of the inner gauze should be kept as large as possible.

### V.—LAMP WITH CHIMNEY (MUESELER LAMP).

A similar lamp was used with a single No. 20 conical gauze (Q=7·25) 4 inches high, the glass was 2·8 inches and 2 inches wide, the chimney was 2·8 inches high, and 1·08 inches diameter at bottom, and ·64 inch diameter at top, and the diaphragm consisted of a gauze or open brass disc.

| No. | Length of Chimney below Disc. | Wire Gauze Diaphragm. | | | Propagation of Explosion Intervals for various heights of the point of ignition : | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | In Axes of Lamp. | | Near Side of Glass. | | |
| | | Total Surface. | Open Surface. | Quotient of Safety. | ·4 Inch. | 1·2 Ins. | ·4 Inch. | 1·2 Ins. | 2·2 Ins. |
| | Inches. | Sq. Inches. | Sq. Inches. | | | | | | |
| — | — | Without Chimney | | — | 18 | 20 | — | — | — |
| 23 | 1·00 | 2·28 | ·76 | 10 80 | 44 | 36 | 40 | 42 | 34 |
| * | 1·00 | 2·28 | ·87 | 5·82 | 32 | 24 | — | — | — |
| † | 1·00 | 2·28 | 1·52 | — | 50 | — | — | — | — |
| † | 1·12 | 2·28 | 1·52 | — | 44 | 40 | — | — | — |
| † | 1·60 | 2·28 | 1·52 | — | 46 | — | — | — | — |

It will be seen that the chimney considerably increases the danger of the propagation of explosion, that the greatest safety was found with the brass disc, and that the lamp becomes more dangerous as the open surface of the gauze becomes smaller.

* A gauze with wires ·0165 inch diameter, and 558 meshes per square inch.

† A brass disc used with annular openings between concentric rings.

VI.—LAMPS WITH AIR ADMITTED BELOW THE GLASS CYLINDER.

The glass cylinder was 2·8 inches high and 2 inches wide, single gauzes were used 4 inches high of No. 18, No 20, and No. 23 mesh. The rings for the admission of the air were of five patterns; in three gauzes of No. 18, No. 20, and No. 23 mesh, and a surface of 1·32 square inches were supported by a metal ring with eight large circular holes, ·4 inch diameter; the fourth and fifth were perforated plates, (A) with 84 holes ·06 inch diameter, and (B) with 78 holes ·04 inch diameter.

| Air Ring. | | Propagation of Explosion Intervals, the height of the point of ignition being ·4 inch, with Gauzes. | | |
|---|---|---|---|---|
| Kind Used. | Open Surface of Wire Gauze. Square Inches. | No. 23. Q = 10·80. | No. 20. Q = 7·25. | No. 18. Q = 4·36. |
| None ... ... ... | 0 | 4 | 20 | 38 |
| No. 23 wire gauze ... | ·45 | 26 | 22 | 26 |
| No. 20 ,, ... | ·51 | 38 | 36 | 38 |
| No. 18 ,, ... | ·62 | 46 | 46 | 48 |
| B ring ... ... ... | ·09 | 40 | 46 | 50 |
| A ,, ... ... ... | ·23 | 62 | 58 | 56 |

It is clear that the introduction of the air below the glass cylinder, either through wire gauze or a perforated ring, favours the passage of the flame through the lamp, the latter arrangement being the most dangerous.

VII.—DAMAGED WIRE GAUZES.

A lamp was used with a glass cylinder 2·8 inches high and 2 inches wide; the conical wire gauze was 4 inches high and made of various meshes, four of whose adjacent mesh holes were converted into one.

| Position of the Hole. | Propagation of Explosion Interval, the height of the point of ignition being ·4 inch, with Gauzes. | | | |
|---|---|---|---|---|
| | No. 23. Q = 10·80. | No. 10. Q = 10·45. | No. 11. Q = 7·38. | No. 19. Q = 5·37. |
| None on side of wire gauze ... | 0 | 0 | 16 | 30 |
| ·4 inch from bottom ... ... | 30 | 20 | 30 | 38 |
| In middle ... .. ... ... | 28 | 26 | 40 | 44 |
| ·4 inch from top ... ... ... | 26 | 26 | 30 | 44 |
| On top of wire gauze in middle | 24 | 40 | 40 | 48 |
| Area of the hole in square inches | ·0017 | ·0025 | ·0029 | ·0034 |

M. W. B.

## SOME RESULTS OF RECENT AMERICAN BORINGS.

*Neuere in Nordamerika mit Diamant-Bohrmaschinen ausgeführte Bohrungen.* By E. GAD. *Berg-und Hütten-männische Zeitung, Vol. XLVII., No. 47, pp. 427 and 428.*

The American Rock Boring Company, of New York, have published some particulars of work done in recent years by their improved Diamond Boring Machine.

Work done at Girard, in Kansas, with a 19½ inch borer, gave the following results:—

| | Total Depth of Borehole. Yards. | Total Time in Boring. Hours. | Advance per Hour. Yards. | Formation. |
|---|---|---|---|---|
| Total in 1885 ... | 1,606 ... | 642 ... | 2·5 | Sandy Slate and Iron Pyrites. |
| At Williams ... | 36 ... | 10 ... | 3·6 | |
| ,, Carbon ... | 37 ... | 10 ... | 3·7 | Fossil-bearing Seams. |
| ,, Magie... ... | 35 ... | 10 ... | 3·5 | |
| ,, Hadges ... | 35½ ... | 10 ... | 3·55 | Chalk and Sandstone. |
| ,, Potter ... ... | 36 ... | 10 ... | 3·6 | Coal and Iron Pyrites. |
| ,, Greaves ... | 34¾ ... | 10 ... | 3·47 | |

The average cost was 6·3 shillings per running yard, and was rendered the greater by water having in some cases to be carried from a distance. The machine was on wheels, and was moved a distance of 124 miles over wet prairie land.

Ten borings in the deep coal seams of Pennsylvania gave the following:—

| | | | Cost. | | | | Rate of Advance. | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Duration. | Depth | Daily Work. | Diamonds. | Fuel and Plant Expenses. | Total. | No. of 10-hour Shifts. | Advance per Shift. | Max. per Shift. |
| | Days | Yards. | £ | £ | £ | £ | | Yards. | Yards. |
| 1. ..... | 60 | 242 | 59·4 | 27·9 | 30·0 | 117·3 | 54 | 4·37 | 8·70 |
| 2. ..... | 25 | 155 | 55·9 | 27·2 | 22·3 | 105·5 | 25 | 7·05 | 14·10 |
| 3. ..... | 15 | 122 | 57·3 | 25·1 | 11·8 | 94·3 | 14 | 8·74 | 14·90 |
| 4. ..... | 38 | 215 | 55·9 | 27·2 | 34·9 | 118·0 | 40 | 5·32 | 17·65 |
| 5. ..... | 26 | 171 | 41·2 | 19·5 | 7·7 | 68·4 | 24 | 7·10 | 11·20 |
| 6. ..... | 35 | 180 | 54·5 | 31·4 | 22·3 | 108·2 | 31 | 5·80 | 9·60 |
| 7. ..... | 44 | 112 | 65·6 | 34·9 | 12·5 | 113·1 | 21 | 5·57 | 8·70 |
| 8. ..... | 17 | 102 | 45·4 | 13·9 | 10·5 | 69·8 | 14 | 7·93 | 9·45 |
| 9. ..... | 16 | 117 | 46·8 | 15·3 | 11·2 | 73·3 | 14 | 8·92 | 9·80 |
| 10. ..... | 8 | 93 | 41·2 | 41·9 | 10·5 | 93·6 | 14 | 15·40 | 15·40 |

Borings carried out for the Croton Water Works during the last four years give the following results:—

| Months. | Undertakings. No. | Holes. | Total Depths. Yards. | Time. Hours. | Mean Depths. Yards. | Average Advance per Hour. Yards. | Formation. |
|---|---|---|---|---|---|---|---|
| 2 | 1 | 7 | 94 | 52·3 | 13·4 | 1·78 | Clay, Slate, Sand, Quicksand, Gravel, Rubble, Hard, Pan, Hard and Soft Stone. |
| 7 | 2 | 49 | 694 | 1,371·7 | 14·2 | ·49 | |
| 32 | 3 | 42 | 855 | 1,403·5 | 20·4 | ·60 | |
| 35 | 4 | 18 | 740 | 1,050·0 | 41·2 | ·70 | |
| 6 | 5 | 15 | 240 | 421·2 | 16·0 | ·55 | |
| 15 | 6 | 18 | 263 | 519·0 | 14·6 | ·50 | |
| 3 | 7 | 13 | 227 | 285·0 | 17·4 | ·79 | |
| 3 | Quaker Bridge Dam | 5 | 130 | 299·0 | 26·0 | ·43 | |
| 2 | Muscoot Dam | 5 | 93 | 72·0 | 18·6 | 1·28 | |
| | Total ... | 172 | 3,336 | 5,473·7 | 18·0 | ·55 | |

A. R. L.

## EARTH TREMORS.

*Les Mouvements vibratoires du Sol déterminés par un Effondrement intérieur aux Houillères de Montrambert (Loire).* By — PRIMAT. *Annales des Mines, Series 8, 1888, Vol. XIV., pp. 526-9. Plate XIII.*

About 9 a.m. on January 13, 1888, a miner working in the Littes Seam, worked from the Devillaine pit of Montrambert Collieries, was severely injured under the following circumstances :—

The Littes Seam is from 3 feet 4 inches to 4 feet thick, and inclined from 40 to 45 degs. The roof consists of a thick and compact sandstone. The seam is worked by longwall, stowed carefully, the face being kept at about right angles to the full dip, and the gateways being level in the seam.

At the time of the accident, a number of workmen were employed in the 1,000 feet level taking out a small block of coal, and in two places immediately below that level, without any previous warning, the roof fell over a large area. The workmen heard a violent noise, due to the fracture, no doubt, of the beds of the roof, and a rapid expulsion of air extinguished all lamps within a radius of 100 yards. All the timber was broken for a length of 250 feet between the 1,000 feet and 1,170 feet levels. The whole of the 1,000 feet, 110 feet long, and adjacent to the block of coal being removed was nearly closed by the crushing of the coal, and the injured workman was found in the middle of it. Many of the other workmen were injured by pieces of coal, violently detached.

At the same time feeble shocks, like those of an earthquake, were felt at numerous points on the surface, in all directions from the place of the fall, the maximum distance where they were felt being about 8,200 feet from the fall. The fall affected about 6,000 square yards of the Littes Seam ; and the packing which had yielded to the pressure of the roof represented about 41 per cent. of the coal extracted. The seam having a thickness of 3 feet 4 inches to 4 feet, the maximum movement of the roof could not have exceeded 1½ to 2 feet.

M. W. B.

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## SWEDISH MINERAL STATISTICS.

*Bergshandteringen i Sverige, åren 1886 och 1887.* By - EVG. SVEDMARK. *Geologiska Föreningens Förhandlingar. Band X., Häfte 7, pp. 477-484. Stockholm, 1889.*

| | Number of Mines in the Years 1886. Mines. | 1887. Mines. |
|---|---|---|
| Iron ore has been worked in ... ... ... | 726 | 655 |
| Gold do. do. ... ... ... | 1 | 1 |
| Silver and lead ores have been worked in ... | 26 | 27 |
| Copper ores do. do. | 13 | 10 |
| Nickel ores do. do. ... | 3 | 1 |
| Cobalt ores do. do. ... | 2 | 2 |
| Zinc ores do. do. ... | 25 | 37 |
| Manganese ores do. do. ... | 22 | 14 |
| Molybdenite do. do. ... | — | 1 |
| Pyrites do. do. ... | 2 | 3 |
| Totals ... ... ... | 820 | 751 |

MINERAL ORE PRODUCTION.

| | Year 1886. Tons. | Cwt. | Year 1887. Tons. | Cwt. |
|---|---|---|---|---|
| Iron ores ... ... ... | 854,361 | 10 | 888,468 | 16 |
| Gold ore ... ... ... | 862 | 12 | 1,382 | 13 |
| Silver and lead ores... .. | 14,685 | 13 | 15,378 | 2 |
| Copper ores ... ... ... | 20,564 | 3 | 20,338 | 4 |
| Nickel ores ... ... ... | 506 | 10 | 83 | 12 |
| Cobalt ores ... ... .. | 161 | 4 | 227 | 12 |
| Zinc ores ... ... .. | 47,240 | 9 | 45,536 | 8 |
| Manganese ores ... ... | 7,082 | 8 | 8,527 | 1 |
| Molybdenite .. ... ... | — | | | $0\frac{1}{3}$ |
| Pyrites ... ... ... | 1,439 | 5 | 2,468 | 2 |
| Totals ... ... | 946,903 | 14 | 982,410 | $10\frac{1}{3}$ |

In the above and in the following tables the Swedish centner of 100 skålpunds is taken as equivalent to ·8372 cwt. English.

The amount of bog iron ore raised in 1886 was 4,825 tons, and in 1887 958 tons.

The author proceeds to enumerate the amounts of iron ore raised in each province of Sweden in the years 1886-1887, and gives also a table of the particular districts which produced the largest quantities of iron ore in those two years—Klackberg and Dannemora stand highest.

COAL PRODUCTION IN THE PROVINCE OF MALMÖHUS.

| | Year 1886. Cubic Feet (English). | Year 1887. Cubic Feet (English). |
|---|---|---|
| Höganäs coalfield ... ... ... | 2,205,526 | 2,318,785 |
| Billesholm (Vallåkra Company) ... | 2,463,625 | 2,459,513 |
| Bjuf (Kropp's Company) ... ... | 1,950,954 | 1,767,697 |
| Boserup (Boserup Company) ... ... | 33,082 | 38,411 |
| Skromberga ... ... .. ... | 912,246 | 922,720 |
| Total ... ... ... | 7,565,433 | 7,507,126 |

The Swedish "Kubikfot" is reckoned equal to 1,601 cubic inches English, = say ·93 cubic feet English.

IRON MANUFACTURE.

| | Year 1886. Tons. | Year 1887. Tons. |
|---|---|---|
| Cast iron production .. ... ... | 435,716 | 449,669 |

(In both years the number of furnaces in blast was 164).

A table is given showing the number of blast furnaces, the average production, and average working times in every fifth year from 1837 to 1887.

| | Year 1886. Tons. | Year 1887. Tons. |
|---|---|---|
| Castings ... ... ... .. ... | 20,814 | 30,053 |
| Wrought iron production ... ... | 233,517 | 251,492 |
| Steel (Bessemer and Siemens-Martin)... | 77,039 | 109,865 |

Following these are detailed statistics of the silver and copper production, and general tables of the other metals extracted from their ores in Sweden during the years 1886 and 1887. L. L. B.

## THE SIMONDS' UNIVERSAL METAL-ROLLING MACHINE.

*Report of the Committee on Science and Arts, Journal of the Franklin Institute, Vol. CXXVI., 1888, pp. 345-369. 2 Plates.*

This invention affords a means for the economical and accurate production from any ductile or malleable metal of any article of circular or approximately circular form, other than simple cylinders. This is effected by swaying dies moving in opposite directions, with surfaces which approach each other, and first roll the ductile metal to form, and afterwards produce by continued rolling a finished surface.

This invention differs from other devices for like purposes, in the extension or drawing of the metal of a rod in the direction of the axis, attended with a reduction of diameter in whole or in part, in distinction from attempting to shorten or upset the metal and thicken portions of the metal to a greater diameter than that of the rod, and with the further feature of the avoidance of any attempt to finish the surface until the metal has been shaped in the form required for the finished article.

The machine consists of vertically reciprocating sliding tables, moving in guides simultaneously at equal velocities, in opposite directions, by racks and pinions, propelled by a train of toothed gearing operated by pulleys turning in reverse directions, and alternately engaged therewith by a coupling or clutch, the coupling being operated by a shifter, participating in the motion of the gearing propelling one of the slides; one of the guides and its sliding table is adjustable, as to distance from the other, so as to make the required changes in the diameter of the work produced.

The dies are fixed to the inner sides of the slides, and are of such a form that as one descends and the other ascends the space between them diminishes. A heated bar of metal placed between them is rolled thereby, whilst its axis retains the same position. The working faces of the dies are inclined as to the direction of their motion, so as to draw the metal lengthwise, in the direction of the axis of the bar, on material of requisite strength and homogeneity.

The machines are adapted for the forging of car axles and similar articles, car wheels, circular and spherical articles, hollow shells and conical projectiles. The invention is successfully applied to the manufacture of articles of prismatic and other forms of cross sections in parts, and with screw threads, such as railway bolts.

Particulars are added of machines invented for similar purposes by Bundy, Bruff, White, Hollingsworth, Reese, Allen, Robertson, Croft, Harwood and Mickle, Boeklen, and Clark and Harvey. M. W. B.

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## AN INVESTIGATION OF SOME EXPERIMENTS ON A CENTRIFUGAL BLOWER DELIVERING AIR INTO THE ATMOSPHERE AT LARGE.

*By* — Isherwood. *Journal of the Franklin Institute, Vol. CXXVII., 1889, pp. 283-293.*

An extensive series of experiments were made by Assistant Engineer-James J. Berry, of the U.S. Naval Engineers, on a Sturtevant centrifugal blower. It received its air from the still atmosphere of a large room, and delivered its air into the same. The experiments were made at velocities varying from 1,250 to 1,950 revolutions per minute.

The following generalisations are deduced from these experiments :—

(*a*) The quantity (volume and weight) of the same air delivered per revolution is constant ; let the number of revolutions made in a given time be what it may.

(*b*) The velocity of the air delivered is in the direct proportion of the number of revolutions made in a given time.

(*c*) The velocity of the centre of the surface of the flat blades is the same as the velocity with which the air is delivered.

(*d*) For any number of revolutions in a given time, the air pressure above the pressure of the atmosphere, re-acting against the surface of the flat blades, and existing in the annular space between the periphery of the blades and the circular side of the case, and causing the velocity with which the air is delivered, is equal.

(*e*) The velocity with which the air is delivered at the outer end of the delivering cylinder, is the velocity due to the excess of the air pressure at the inner end of the delivering cylinder above the atmospheric pressure. This excess of pressure being known, the velocity can be calculated, and *vice versa*.

(*f*) The velocity with which the air is delivered at the outer end of the delivering cylinder is in the ratio of the square root of the above excess of pressure. Inversely, the above excess of pressure is in the ratio of the square of the number of revolutions made by the blower in a given time.

(*g*) When the velocity of the air is suddenly extinguished, the same excess of pressure, above the atmosphere, that caused the velocity is re-produced.

(*h*) The work done by the blades upon the inflowing air is measured by the above excess of pressure per square inch, multiplied by the aggregate area of the blades in square inches, and by the velocity of the centre of the surface of the flat blades in feet per minute. This, however, is *not* the work done by a motor driving the blower, as such work must include, in addition, the difference between the quiescent atmospheric pressure and the pressure of the inflowing air against the back of the blades, and the friction of the motor.

(*i*) The work done by the outflowing air is measured by the above excess of pressure per square inch, multiplied by the cross area of the delivering cylinder in square inches, and by the velocity of the outflowing air in feet per minute.

(*j*) As the velocity of the centre of the surface of the blades is the same as the velocity of the outflowing air, and as the pressure above atmospheric pressure produced by the blades is the same as the pressure producing the velocity of the outflowing air, the work done by the blades on the air, and the work done by the outflowing air, are in the direct ratio of the aggregate area of the blades to the cross area of the delivering cylinder.

(*k*) The number of cubic feet delivered per minute is measured by the cross area of the delivering cylinder in square feet, multiplied by the velocity of the air issuing from that cylinder in feet per minute, and by ·82 for the co-efficient of discharge.

(*l*) Of the entire quantity of air entering the blower and put in motion by the blades, one-third is brought to rest within the case, after which it is again set in motion by the blades with its original velocity.

(*m*) The theoretical co-efficient of the blower as a furnisher of air is ·66, including the air leakage ; its practical co-efficient does not exceed ·30 : and

(*n*) The resistance of the blower is as the square of the number of revolutions made in a given time ; the power required to drive the blower, irrespective of the motor, is as the cube of the number of revolutions made in a given time.

M. W. B.

## THE FOHNSDORF COALFIELD (STYRIA).

*Der Kohlenbergbauim Sillweger Fohnsdorfer Kohlenbecken.* *By* CARL BARTH. *Berg- und Hütten-männische Zeitung, Vol. XLVII, 1888, pp. 289-292; 297-300, Plate VIII, containing Map and 19 Figures.*

This coalfield lies on the river Mur in Styria, and is of Tertiary formation. The length from east to west is about 10 miles, and from north to south about six miles.

The coal has the following composition :—

| | Sillweg. | | | Anthony. | |
|---|---|---|---|---|---|
| | Round Coal. | Small Coal. | Large Coal. | Round Coal. | Small Coal. |
| Carbon ... ... | 46·80 | 44·70 | 49·58 | 46·51 | 36·47 |
| Ash ... ... ... | 15·70 | 12·30 | 10·42 | 32·30 | 22·63 |
| Volatile matter ... | 19·45 | 27·03 | 25·75 | 13·20 | 26·72 |
| Sulphur ... ... | ·45 | ·97 | 1·05 | 2·80 | 1·35 |
| Water ... ... | 17·60 | 15·00 | 13·20 | 5·19 | 12·83 |
| | 100·00 | 100·00 | 100·00 | 100·00 | 100 00 |

Only one seam, more or less divided by intercalated bands of shale and sandstone is worked with a thickness varying from 6 to 16 feet, and an inclination varying from 20 degs. to 40 degs. The workings are upon the bord and wall system, the pillars being removed in lifts in the direction of the full rise of the seam, the coal being run down to the level by self-acting inclines. M. W. B.

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## THE SULPHUR MINES OF SICILY.

*By* PHILIP CARROLL *The Engineering and Mining Journal (New York), 1888, Vol. XLVI, pp. 174-175, 192.*

*History.* Sulphur mines have been worked in Sicily for over 300 years, and exports were small until 1820.

*Resources.*—The annual production amounts to about 400,000 tons per annum from nearly 300 mines, and, as the supply is estimated at 30 millions of tons, the mines will be exhausted in about 75 years.

*Laws.*—By a law passed in 1819, the mines are the property of the landowner, who has the right to work the property or let it to others; if he fails to do so, the State may let them on its own account. Royalties vary from 12 to 15 per cent., according to the quality of the ore and the facilities for producing sulphur, an average being about 25 per cent. There is a land tax of 36 per cent. of the net income paid by lessees, and an export duty of 8s. per ton The mines are inspected by State officials once a year, and the lessees are required to furnish plans of the workings to the State. Leases are usually made for 9 years, in some cases considerable sums are paid for the lease, and the royalty is then reduced to 15 or 20 per cent.

*Mining Operations.*—The appearance of gypsum and sulphurous springs are the external evidence of the existence of sulphur. A small pit, inclined at an angle of 30 degs. to 50 degs., and which is fitted with steps for the use of the workmen, is then sunk in order to reach the mineral. When the sulphur is found the passages are driven in it in all directions, as the seams of mineral lie very irregularly.

Where the ore is rich, and the matrix yielding, it is detached by means of picksand pinches, in other cases gunpowder is employed. Boys are used to carry the ore to the surface. Pillars of rock and ore are left in order to support the roof of the excavations, which frequently take the form of immense caves. The galleries are walled and cemented with gypsum. It frequently happens, however, that the galleries and caverns give way, with great destruction of life and property.

The deepest mines are about 500 feet. Water is found frequently, and primitive wooden hand-pumps are constantly employed.

Steam is used at the more important mines to actuate the hoisting apparatus and steam pumps. English coal is used, and costs £2 per ton at the mine.

Open lights are used in all the mines, in certain places an earthenware lamp is employed, said to be a *facsimile* of those used by the Phoenicians.

Fire-damp is occasionally found when the ventilation is not good.

The most serious danger is the ignition of the mine, which, once on fire, may burn for years. In such cases all inlets and outlets are sealed in order to shut off the air, but, notwithstanding these precautions, the gases escape through the innumerable fissures and openings, and the ingress of air makes it almost impossible to extinguish the fire, so it frequently happens that the conflagration continues indefinitely or until the mine is exhausted. In some cases the burning of a mine is an advantage to the owners, as it dispenses with the smelting and produces natural refined sulphur.

*Cost of Mining.*—Galleries are usually driven 4 feet by 6 feet, and the labourers are paid as follows:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Siliceous limestone | | 44s. | per yard, and drive | | ·82 | feet per shift. |
| Gypsum | do. | 36s. | do. | do. | 1·00 | do. |
| Marl | do. | 22s. | do. | do. | 1·65 | do. |
| Clay | do. | 11s. | do. | do. | 3·30 | do. |

Miners are paid about 3s. 6d. per ton of ore.

In some cases they are paid by the ton of fused sulphur, say from 32s. to 40s.

Each miner works about 1½ tons of ore daily, and employs boy-assistants to carry the ore. When the mine is under 125 feet in depth one boy is employed, two boys up to 200 feet, and three boys up to 300 feet. These boys are from 7 to 16 years of age, carry from 1,000 to 1,500 pounds of ore per shift of 6 to 8 hours, and are paid from 8d. to 1s. 3d. per day.

*Workmen.*—The food of the miners consists of bread, oil, and wine or water, and sometimes cheese, macaroni and vegetables are added.

The miners are usually unable to read or write. In some cases, suitable dwellings are provided, but they frequently live and sleep in the mines or in the open air, according to the weather.

There is a relief fund for accidents, maintained by a deduction of 1 to 2 per cent. from the miners' wages.

There are about 25,000 miners.

*Extraction of the Sulphur.*—The ore is subjected to heat for the extraction of the sulphur, in kilns locally known as "calcaroni." The kilns are operated in

the open air, and are capable of melting, according to size, from 40 to 5,000 tons. Part of the sulphur is burnt in the process of smelting, in order to liquefy the remainder.

The kilns (calcaroni) are usually situate on the side of a hill, in order that the fused sulphur may flow downwards in the prepared channels.

The kilns are circular, and the floor has an inclination of 10 degs. to 15 degs. The outer wall is made of rubble work, cemented with gypsum; the wall is about 1½ feet thick at the back, and thickens to the front, where it is 3 feet when the diameter is 30 feet. An opening 4 feet high and 1 foot wide is left in the front, through which the fluid sulphur flows. Two walls 2½ feet thick are built on each side of the opening and at right angles to the outer wall, in order to strengthen the front of the kiln. A small room is formed between these walls by the addition of a door and a roof, in which the keeper resides, until the termination of the flow of sulphur.

The inclined floor of the kiln is made of rough stones, 8 inches thick, covered with "ginesi," the refuse of a former smelting, to a thickness of 10 inches, increasing to the front of the kiln.

The outer wall is 12 feet high at the front, and 6 feet high at the back, and is rendered impermeable by a plaster of gypsum.

A calcarone of 500 tons capacity costs £30.

Smelting with a calcarone of 200 tons capacity requires 30 days, 800 tons 60 days, and 2,000 tons from 90 to 120 days.

In filling or loading a calcarone, the larger blocks of ore, and the most sterile, are placed at the bottom, and near the mouth, in order to keep the lower part of the kiln as cool as possible, and to prevent the liquid sulphur from becoming ignited as it passes downwards to the exit. The foundation completed, the building of the "pile" is proceeded with, the larger blocks being placed in the centre to form the "backbone," the smaller blocks being placed on the outside or in the interstices. The "pile," when completed, is shaped like a truncated cone, and, when burning, looks like a small volcano. When the kiln is loaded, it is covered entirely with "ginesi," in order to prevent the escape of fumes.

The ore is ignited by means of bundles of straw, held above the top of the cone, which is at once closed with ginesi, and the calcarone left untouched for about a week.

During the process the flames descend gradually, and the sulphur in the ore is melted by the heat from above. In 7 or 8 days sulphurous fumes and sublimed sulphur begin to escape, and a new coat of ginesi is added to prevent damage to vegetation by sulphur fumes. The mouth of the kiln is then closed with gypsum, in order to stop any draught. As the sulphur is liquefied it passes to the most depressed side of the kiln and solidifies upon encountering the cold and sterile blocks. It is again liquefied by means of burning straw, and an iron trough is inserted into a mouth made in the kiln for the purpose; the reliquefied sulphur pours into the trough, from which it is run into wooden moulds called "gadite," which are kept cold by being submerged in water.

The sulphur is taken out of the mould, when cool, in solid blocks weighing about 100 pounds, two of which are a mule load. It occasionally happens that a kiln is lost by the sulphur cooling before it comes to the mouth.

A ton of ore containing about 25 per cent. yields only 300 pounds of sulphur.

Labourers are paid 4d. per ton for loading and unloading kilns, and from 30 to 40 men are employed at a time. The keeper of the "calcarone" is paid from 1s. 8d. to 2s. per day.

Notwithstanding the many defects of the "calcarone," it is the cheapest and simplest mode of smelting, and is preferred to any system requiring machinery and skilled labour.

The principal furnaces in use are:—Durand's, Hirzel's, Gill's, and Kayser's system of fusion; Conby Bollman process; Thomas' steam process of smelting; and Gill's recuperative kilns. (These are not described).

*Grades of Sulphur.*—There are several qualities:—

| | Price per ton at Ports Empedocle. | | Licata. | | Catania. | |
|---|---|---|---|---|---|---|
| | s. | d. | s. | d. | s. | d. |
| 1. First quality almost chemically pure, of a very bright and yellow colour ... ... ... ... | ? | | ? | | ? | |
| 2. Second best, slightly inferior, bright and yellow | 68 | 9 | 69 | 1 | 72 | 0 |
| 3. Second good, contains 4 to 5 per cent. of earthy matter, but is bright yellow ... ... ... | 67 | 0 | 67 | 1 | 71 | 8 |
| 4. Second current, dirty yellow, and containing more earthy matter ... ... ... ... | 66 | 7 | 66 | 7 | 70 | 2 |
| 5. Third best, brownish yellow, this tint depends upon the amount of bitumen (?) ... ... ... | 62 | 9 | 63 | 6 | 69 | 0 |
| 6. Third good, light brown, containing much foreign matter ... .. ... ... ... ... | 61 | 9 | 61 | 9 | 65 | 11 |
| 7. Third current, brown and coarse ... ... ... | 61 | 0 | 60 | 11 | ? | |

The sulphur is conveyed by rail in carts, or on mules or donkeys to the seaboard. The tariff by road is 10d. per ton per mile, and by rail 1·85d. per mile, and is about to be reduced to 1d. The extension of the railway systems has been of great advantage to the sulphur industry, by reducing the cost of transport before shipment.

M. W. B.

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## THE MINES AND WORKS OF ALMADEN.

*Les Mines et Usines d'Almaden. By* G. Gandolfi. *Revue Universelle des Mines, &c., 1889. Vol. VI., pp. 175-207, 221-229. Plates 9 and 10.*

Almaden (in the language of the Moors, the "mines") has been known since time of Julius and Augustus Cæsar, Theophrastus and Pliny. The mines were leased from 1525 to 1645 to a German firm.

The rock injected with cinnabar, which forms the ore of Almaden, is a very hard quartzite, in Silurian strata. There are three parallel veins following the average inclination of the strata, 80 degs., and running from south-east to north-west.

### I.—WORKINGS.

The characteristics of the mode of working of the mines consist in the maintenance of the walls of the vein by masonry. The removal of the mineral is made by rises, and partially replaced by masonry and stowing. The stages are worked downwards, the levels being from 25 to 30 yards apart. Finally the long vertical mass is removed by means of the short galleries built in the stowing and masonry.

The mineral is conveyed on tramroads of 31 inches gauge, in tubs carrying about 8 cwt.

There are three shafts, each about 14 feet by 5 feet, 300 yards deep, fitted with winding engines, flat steel ropes, Cornish boilers, cages carrying two tubs, oak guides, &c.

The water is pumped by a Watt engine, erected in 1791. The mines are ventilated by natural means.

II.—MECHANICAL PREPARATION OF ORES.

The ore is passed over screens and separated into four sizes, passing over 4·8 inches, 1·2 inches, and ·6 inches, and through ·6 inches. The larger pieces are broken by hand, and separated into a series of classes, containing the following percentage of mercury, 20-25, 10-12, 7-9, and 1¾-2, the average being from 7-9 per cent.

III.—METALLURGICAL TREATMENT.

The ore is treated in thirteen furnaces, eleven Bustamente, one Idrian, and one modified Livermoor.

There are four small and seven large Bustamente furnaces, costing about £600 each, charged with 1950 pounds, and 2900 pounds of ore respectively. About 1500 and 2000 pounds of coal are used, the operation lasting for three or four days. The mercury is condensed in small pipes, and flows to a central channel, where it is collected. The loss of metal is from 4 to 5 per cent.

In the Idrian furnace the condensation is effected in twelve large chambers, in which the gases circulate up and down, and the mercury is collected in a channel. The charge is about 60,000 pounds of ore, and the operation of burning lasts six days. The loss of metal is about 6·2 per cent. Cost of a furnace, £8500.

IV.—STORAGE, &c.

The mercury is placed in wrought-iron bottles, weighing 13 pounds, and containing 75 pounds.

V.—STATISTICS, &c.

The article concludes with tabular summaries of the costs of working per ton of ore and of mercury, the produce of ore, &c., for several years. The average cost of a ton of mercury being about £40, and the annual production about 1700 tons of mercury, from about 18,000 tons of ore.

M. W. B.

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## GEOLOGY OF THE LOWER CONGO.

*Esquisse Géologique du Bas-Congo: de l'Embouchure (Banana) à Manyanga et au delà vers le Stanley Pool.* By H. Z. Boinski. *Revue Universelle des Mines, &c., 1889, Vol. VI., pp. 31 to 39, and Plate 5.*

The Lower Congo, from Banana to Stanley Pool, may be divided into six zones:—

1. Littoral deposits.
2. Estuarine formation.
3. Sub-littoral deposits of rocks more recent than red sandstones of the upper parts of the cataracts; they are probably of Tertiary age, at least in the vicinity of the coast.
4. Primitive rocks, comprising:—
   (*a*) those whose quartzites are impregnated with tourmaline; and
   (*b*) those where mica schists are most prominent.
5. Slate rocks.
6. Red schists and sandstones.

M. W. B.

## TEST FOR CARBONIC OXIDE GAS.

*Les Progrès réalisés dans l'Industrie du Gas d'Eclairage.* By CAMILLE ROLLAND. *Revue Universelle des Mines, &c., 1889, Vol. VI., pp. 273-292.*

This test consists in utilising the extreme affinity possessed by chloride of platinum for carbonic oxide gas. The reagent consists of—

| | |
|---|---|
| Chloride of platinum ... ... ... .. | 3·75 grammes. |
| Chloride of gold ... ... ... ... ... | 1·25 ,, |

dissolved in a litre of water.

Slips of paper, ½ inch wide and 2 inches long, are prepared with the solution, which must not saturate them, and are used inside of short glass tubes.

M. W. B.

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## THE BELMEZ-ESPIEL COAL-FIELD (SPAIN).

*Le Bassin Houiller de Belmez-Espiel.* By G. GANDOLPHI. *Revue Universelle des Mines, &c., 1889, Vol. V. pp. 187-213, Plate V.*

The Belmez-Espiel coal-field is one of the best in Spain, as regards quantity and quality of the coal. It is situated north-west of Cordova, in the centre of the Sierra Moreña, and in the valley of the Guadiato. It has a length of 37 miles, a mean breadth of 2,800 yards, the maximum breadth being about 5,000 yards.

This formation of sedimentary rocks has a dip of 45 degs. to 50 degs. N. 40 degs. W., resting upon Silurian schists and quartzites. The measures are characterised by sandstone conglomerates and argillaceous schists, and a few beds of argillaceous carbonate of iron. The coal seams are usually found between the sandstone and schists.

The principal collieries are worked by two companies. The Andalusian Railway is working three concessions—Santa Elisa, Santa Ana, and San Marcellino—and produce about 136,000 tons of coal annually. The Belmez Coal and Iron Company work about 110,000 tons of coal per annum.

The paper contains full details of the plant, workings, &c., of these collieries, &c. The coal is somewhat liable to spontaneous combustion. Fire-damp is found in such quantities as to cause serious explosions from time to time.

ANALYSIS OF COAL, ETC.

| | Santa Elisa. | Cabesa de Vaca. | Espiel. |
|---|---|---|---|
| Fixed Carbon ... ... | 73·10 | 52·38 | 65·0 |
| Ash ... ... ... | 2·60 | 12·30 | 12·0 |
| Volatile matter ... | 24·30 | 35·32 | 23·0 |
| Coke ... ... ... | 75 | 68 | 77 |
| Elements— | | | |
| Carbon ... .. ... | 83·33 | 73·15 | — |
| Hydrogen ... ... | 5·02 | 4·72 | — |
| Oxygen ... ... ... | 9·05 | 7·83 | — |
| Nitrogen ... ... ... | — | ·50 | — |
| Sulphur ... ... ... | ? | 1·50 | — |
| Ash ... ... ... | 2·60 | 12·30 | — |
| Calorific power ... ... | 31,666 | 25,333 | — |
| Cubic feet of gas per ton of small coal ... ... | 10,950 | — | — |
| Do. round coal | 11,490 | — | — |

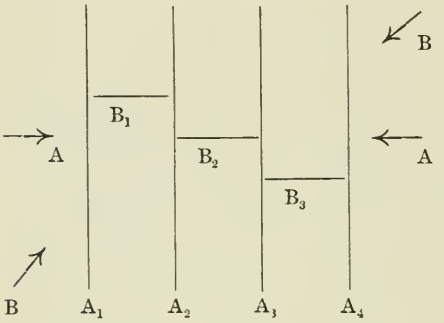
M. W. B.

## A STUDY ON FAULTS.—IS A FAULTED FISSURE ALWAYS THE OLDEST?

*By* CARL HENRICH. *The Engineering and Mining Journal (New York), 1889, Vol. XLVIII., p. 159 and 2 figures.*

While some of the old theories of faults have been modified, the old rule has remained intact, that a faulted or displaced fissure is always the older one.

The correctness of this rule has been questioned owing to recent observations in Aspen district, Colorado, in which the apparently faulted fissure is the younger one, and is in reality not one disjointed faulted fissure, but several independent originally separated fissures.




The tangential pressures in the directions A, as shown by the arrows, will produce the series of parallel or almost parallel faults $A_1$, $A_2$, $A_3$, $A_4$. If after a period of rest the same part is subjected to another sufficient tangential pressure, acting in the direction of the arrows B, faulting will occur along the plane or planes of least resistance. This line of least resistance will not be, as in the case of non-faulted crust, when the pressure A was acting on it, in one continuous line or plane, as this line or lines of least resistance will have been disconnected by the faults $A_1$, $A_2$, &c. The new break or fault formed by the force B, will consequently occur at a different place in each separate rock mass included between each part of the older faults.

M. W. B.

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## EXPERIMENTS WITH EXPLOSIVES.

*Bericht über weitere in der Versuchsstrecke zu Grube König bei Neunkirchen (Saarbrucken) angestellte Untersuchungen bezüglich des Verhaltens brisanter Sprengstoffe gegen Schlagwetter und Kohlenstaub. By* H. LOHMANN. *Zeitschrift für das Berg- Hütten-und Salinen-Wesen, 1889, Vol. XXXVII. pp. 83-108, and Plates.*

The experiments were made at Neunkirchen in 1888 in a new gallery, 5⅔ feet high and 4 feet wide, of elliptic section. The detonation of the explosives was made in a Martin's steel mortar, resembling a shot-hole, whilst those previously made in the old gallery in 1887 were made in the open air. The steel mortar was 19¾ inches diameter and 27½ inches high, with a casing of iron 1½ inches thick. The shot, in the middle, was 18 inches long and 2¼ inches wide. The mortar weighed 3,225 pounds.

All the shots were fired by electricity, and a detonator containing 15 grains of fulminate of mercury, and stemmed with 1⅓ pounds of clay. The experiments made were :—

I. 3·5 ounces, without stemming, without gas, and with coal-dust.

II. 8·8 ounces, without stemming, without gas, and with coal-dust.

III. 8·8 ounces, without stemming, with gas, and coal-dust (most dangerous).

IV. 8·8 ounces, with stemming, without gas, with coal-dust (less dangerous).

V. 8·8 ounces, with stemming, with gas, and with coal-dust.

The explosives are grouped thus:—A, gunpowder; B, nitro-glycerine; C, nitro-glycerine with volatile bodies; D, hydro-carbon and oxygen producer.

A. Powder was found at the head of the dangerous explosives; but it is possible to diminish the danger by incorporating carbonate or oxalate of ammonia with it. Somewhat favourable results were obtained from mixtures of powder and coal-dust, with production of a considerable volume of carbonic oxide gas.

B. Dynamite No. 1 was found to be unsafe. Explosive gelatine was very dangerous. Carbo-dynamite must be classed amongst the most dangerous explosives. Gelatine-dynamite affords no safety in presence of gas and dust.

C. Grisoutite, containing 40 per cent. of carbonate of soda, affords great safety. Another sample containing nitro-glycerine 40, nitrate of potass 7½, sawdust 2½, and sulphate of magnesia 50, also gave good results. Ammonia dynamite consisting of carbonated ammonia 40, nitrate of potass 10, and dynamite 50 (with 75 per cent. of nitro-glycerine), is a very safe explosive, it is similar to grisoutite in its action, and perhaps a little better; it yields more fumes than grisoutite, but they are less disagreeable. Carbonite produces carbon monoxide on explosion; the trials were too few to form a decided opinion as to its safety.

D. Securite appeared to be very safe, it yielded as good results as grisoutite—the fumes were better; but a second sample yielded less favourable results. Roburite should be preserved from moisture; it is said by the makers to contain chlorine, but this metalloid was not discovered on analysis; the experiments showed that it was safer than gelatine-dynamite, and more dangerous than ammonia-dynamite. Favier's explosive consists of a compressed hollow cylinder filled with loose powder of the same composition, and should be preserved from moisture: a sample composed of dinitro-benzin, mononitro-naphthalene, nitrate of ammonia and nitrate of soda was very safe but the experiments were discontinued from want of the explosive. M. W. B.

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## STATISTICS OF MINING, METALLURGY, &c., IN BELGIUM, IN 1884 AND 1885.

*Statistique des Mines, Minières, Carrières, Usines Metallurgiques et Appareils à Vapeur pour les Années 1884-1885. Annales des Travaux Publics de Belgique, Vol. XLIII., pp. 405–432, Vol. XLIV. pp. 229–260.*

COLLIERIES.

| | | 1884. | 1885. |
|---|---|---|---|
| Number ... ... ... ... ... ... ... | | 289 | 285 |
| Production— | | | |
| Hainault ... ... ... ... ... | Tons | 13,510,996 | 12,925,815 |
| Namur ... ... ... ... ... | ,, | 477,439 | 439,953 |
| Liége ... ... ... ... ... | ,, | 4,063,064 | 4,071,835 |
| Total ... ... | ,, | 18,051,499 | 17,437,603 |
| Imports— | | | |
| Coal ... ... ... ... ... ... | ,, | 1,223,691 | 1,238,116 |
| Coke (70 per cent.) ... ... ... ... | ,, | 32,813 | 22,094 |
| Total ... ... | ,, | 1,270,567 | 1,269,679 |

| | | | | |
|---|---|---|---|---|
| xports— | | | | |
| Coal ... ... ... .. ... ... | ,, | 4,619,192 | | 4,338,330 |
| Coke (70 per ent. ... ... .. .. | ,, | 854,258 | | 848,726 |
| Total ... ... | ,, | 5,839,561 | | 5,550,786 |
| Excess of exports over imports ... ... | ,, | 4,568,994 | | 4,281,107 |
| Consumption ... ... ... ... ... | ,, | 13,482,505 | | 13,156,496 |
| Value of production ... ... ... ... | † | £6,809,600 | | £6,120,300 |
| Mean selling price per ton ... ... ... | | 7s. 6·54d. | | 7s. 0·27d. |
| Mean thickness of seams worked ... ... | | 1·93 feet. | | 2·06 feet. |
| Steam Engines— | No. | H.-P. | No. | H.-P. |
| Winding ... ... .. ... ... | 443 | 59,703 | 438 | 60,312 |
| Pumping ... ... ... ... ... | 196 | 31,900 | 201 | 31,905 |
| Ventilating ... .. ... ... ... | 381 | 15,409 | 378 | 15,400 |
| Sundry uses ... ... ... ... ... | 974 | 12,473 | 988 | 12,805 |
| Total ... ... | 1,994 | 119,485 | 2,005 | 120,422 |

| Workpeople underground— | 1884. | 1885. |
|---|---|---|
| Men ... ... ... ... ... ... ... | 64,354 | 63,337 |
| Women ... ... ... ... ... ... | 5,102 | 4,256 |
| Boys under 16 ... .. ... ... ... | 8,660 | 8,489 |
| Girls under 16 ... ... ... ... ... | 2,154 | 1,612 |
| Total ... ... ... | 80,270 | 77,694 |
| Workpeople at bank— | | |
| Men ... ... ... ... ... ... ... | 16,263 | 16,704 |
| Women ... ... ... ... ... ... | 4,051 | 3,847 |
| Boys under 16 ... ... ... ... ... | 2,484 | 2,609 |
| Girls under 16 ... ... ... ... ... | 2,514 | 2,241 |
| Total ... ... ... ... | 25,312 | 25,401 |
| Grand total ... ... ... | 105,582 | 103,095 |
| Wage of work-person, per annum ... ... ... | £36 3s. 7d. | £32 2s. 10d. |
| Do. per day ... ... ... | 2s. 4·98d. | 2s. 2·60d. |
| Annual production per work-person ... ... Tons | 190 | 188 |
| Cost of working— | | |
| Wages ... ... ... ... ... ... ... | £3,818,130 | £3,319,020 |
| Other costs ... .. ... ... ... ... | 2,743,720 | 2,526,680 |
| Total ... ... ... ... | £6,561,850 | £5,845,700 |
| Profit ... ... ... ... | £247,750 | £274,600 |

ACCIDENTS IN COLLIERIES.

| | 1884. | | | 1885. | | |
|---|---|---|---|---|---|---|
| Underground— | Accidents. | Killed. | Injured. | Accidents. | Killed. | Injured |
| Shafts ... ... ... ... | 37 | 27 | 13 | 26 | 24 | 12 |
| Falls of stone, &c. ... ... | 87 | 72 | 16 | 66 | 61 | 11 |
| Fire-damp ... ... ... | 10 | 51 | 13 | 14 | 42 | 34 |
| Suffocation by other gases ... | — | — | — | 1 | 9 | — |

† Franc = 9½d.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Irruptions of water ... ... | 2 | 2 | — | ... | 2 | 5 | — |
| Use of explosives ... ... | 26 | 12 | 21 | ... | 6 | 2 | 5 |
| Engine planes, &c. ... ... | 52 | 37 | 13 | ... | 43 | 29 | 17 |
| Miscellaneous ... ... | 20 | 22 | 2 | ... | 8 | 6 | 2 |
| Total ... ... | 234 | 223 | 78 | ... | 166 | 178 | 81 |
| Surface— | | | | | | | |
| Falling into pits ... .. | 1 | 1 | — | ... | — | — | — |
| Wagons ... ... ... | 1 | 1 | — | ... | 5 | 4 | 1 |
| Engines, machinery, &c. ... | 10 | 9 | 1 | ... | 6 | 3 | 3 |
| Miscellaneous ... ... | 4 | 2 | 2 | ... | 3 | 3 | 1 |
| Total ... ... | 16 | 13 | 3 | ... | 14 | 10 | 5 |
| Grand total ... | 250 | 236 | 81 | ... | 180 | 188 | 86 |

MANUFACTURE OF COKE.

| | 1884. | 1885. |
|---|---|---|
| Coke ovens at work ... ... ... ... ... | 3,919 | 3,733 |
| Do. off work ... ... ... ... ... | 1,787 | 2,004 |
| Coke made ... ... ... ... ... ... Tons | 1,812,148 | 1,678,473 |
| Workmen ... ... ... ... ... ... ... | 2,074 | 2,066 |
| Mean selling price per ton ... ... ... ... | 11s. 9·27d. | 10s. 7·30d. |
| Yield of coke per cent. ... ... ... ... ... | 73·14 | 73·21 |

MINES, FURNACES, ETC.

| | | |
|---|---|---|
| Workmen in mines ... ... ... ... ... | 1,926 | 1,788 |
| Zinc ores produced ... ... ... ... Tons | 27,606 | 18,185 |
| Ores imported ... ... ... ... ,, | 169,587 | 177,218 |
| Zinc manufactured ... ... ... ... ,, | 77,487 | 80,298 |
| Value, per ton ... .. ... ... ... | £13 12s. 1d. | £13 4s. 8d. |
| Imported ... ... ... ... ... Tons | 2,167 | 1,975 |
| Exported ... ... ... ... ... ,, | 63,110 | 61,536 |
| Lead ores produced ... ... ... ... ,, | 1,796 | 1,299 |
| Ores imported ... ... ... ... ,, | 10,939 | 9,029 |
| Lead manufactured ... ... ... ... ,, | 7,751 | 8,656 |
| Value, per ton ... ... ... .. ... | £10 10s. 7d. | £10 9s. 2d. |
| Imported ... ... ... ... ... Tons | 5,750 | 4,900 |
| Exported ... ... ... ... ... ,, | 7,064 | 6,918 |
| Iron pyrites produced ... ... ... ... ,, | 2,243 | 4,533 |
| Iron ores produced ... ... ... ... ,, | 176,755 | 187,118 |
| Ores imported .. ... .. ... ,, | 1,514,187 | 1,468,083 |
| Pig iron manufactures ... ... ... ... ,, | 750,812 | 712,866 |
| Value, per ton ... ... ... ... ... | 39s. 10d. | 36s. 4d. |
| Imported ... ... ... ... .. Tons | 125,619 | 90,726 |
| Exported ... ... ... ... ... ,, | 10,665 | 10,718 |
| Manufactured iron ... ... ... ... ,, | 471,040 | 469,249 |
| Value, per ton ... ... ... ... ... | £5 14s. 2d. | £5 1s. 8d. |
| Manufactured steel ... ... ... ... Tons | 153,999 | 125,461 |
| Value, per ton ... ... ... ... ... | £5 6s. 0d. | £4 18s. 3d. |

QUARRIES.

| | | |
|---|---|---|
| Value of products... ... ... ... ... ... | £1,462,200 | £1,296,200 |

## ON WATER FOR STEAM BOILERS.

*Du Choix et de l'Emploi des Eaux destinées à l'Alimentation des Générateurs de Vapeur. By* — FINEUSE. *Annales des Travaux Publics de Belgique Vol. XLIII. p. 181, Plate II.*

An endeavour should be made to secure a good boiler water, even at great cost, and to avoid, in many instances, the necessity of using some system of disincrustation which is somewhat unsatisfactory. If owners were told, in the beginning, of the danger and costs ensuing on the use of bad water, it is certain that many of them would adopt the best available means.

As soon as the topographical conditions of a district are known, as not permitting the storage, without great cost, of a water less charged with salts than the subterranean sources, the density of the mine water should be tested or a complete qualitative and quantitative analysis should be made before the type of boiler to be used is chosen. As a rule, the system adopted should be the simpler, as the water is less pure, unless the arrangement selected renders the cleansing easy.

Systems of purifying *before* feeding should be preferred, others have the objection of transforming the boiler into a chemical retort and increasing the impurity of the water.

The distillation and the use of condensation water are recommendable systems, but their application is only possible in certain cases.

If the water is only charged with mechanical impurities in suspension, a slow decantation or natural or artificial filtration, will prevent the accumulation of masses of mud.

The filtration of water through spongy iron will remove organic matters. The presence of chloride of magnesia is neutralized by the addition of carbonate of soda.

The separation of carbonate of lime, the most common salt in soft waters, is effected by the use of milk of lime and careful filtration or the action of heat, which precipitates, almost entirely, the carbonate held in solution by the carbonic acid gas.

Sulphate of lime is more difficult to get rid of, and the known means of treatment are capable of considerable improvement.

Chloride of baryta, alkaline silicates, carbonate of magnesia, hydrate of magnesia, have the inconvenience either of being without a practical system or of rendering the water more acid.

Boiling the water at the temperature of 280 degs. to 300 degs. Fah., necessary for the complete removal of sulphate of lime, introduces complications preventing the industrial use of the system.

If the preliminary purification requires very costly plant, or if it is impossible, by this method, to prevent the adherence of the calcareous deposits, disincrustants should be used.

Practice shows that a good system of continuous cleansing of a boiler fed with water, slimy or rich in sufficient carbonate of lime, will keep the sides clean, or at least facilitate the removal of the thin incrustations left on the plates.

No anti-incrustator should be used until the composition of the deposits produced are known, and unless it is known, from time to time, that the deposits do not contain iron and that the presence of this metal is not due to the use of the disincrustant.

If settling, cleansing, or filtration will not prevent the effects of fats in the water, it is desirable to use either carbonate of soda, or a mixture of lime and caustic soda, or preferably use mineral oils instead of animal or vegetable oils in the lubrication of the engines.

The adhesion of deposits, favoured by an oxidation of the metallic surfaces, may be successfully resisted, irrespective of the bad quality of the water, by the use of a coating upon the plates, previously well cleansed.

The use of zinc and electric methods may be of some advantage, but at the cost of great care in the installation and the maintenance of the apparatus.

The same remarks apply to sugared bodies, sal-ammoniac, &c.

Soda is the best disincrustant for sulphate of lime, accompanied by the simultaneous use of the cleansing apparatus.

Lastly, the emptying of the boilers and cleansing of the sides, internal and external, should be periodically and carefully carried out, the plates should be inspected thoroughly after any long stoppage, the thickness of the sides should be verified, whenever local corrosion of the plates necessitates repairs, and the return of a boiler to use should be preceded by a prolonged test with hydraulic pressure. M. W. B.

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## MINERAL PRODUCTS OF NEW SOUTH WALES.

*Department of Mines, Sydney, Mineral Products of New South Wales, by* HARRIE WOOD; *Notes on the Geology of New South Wales by* C. S. WILKINSON; *and Description of the Seam of Coal worked in New South Wales, by* JOHN MACKENZIE, *pp. 1 to 185, and Plates I. to XXII.*

This is a lengthy report upon the mineral resources, coal, gold, copper, tin, iron, silver, lead, antimony, zinc, chromite, manganese, cobalt, bismuth, tungsten, mercury, asbestos, barytes, alum-stone, diamonds, gems, building-stones, marbles, &c., of the colony. It contains statistical tables of the produce of the various minerals for many years. There are numerous analyses of minerals, together with a great many analyses of coals of New South Wales, Great Britain, &c., &c.

The geology is treated in a clear manner, and is accompanied with lists of fossils for each of the sedimentary formations from the Silurian upwards.

Descriptions are appended of the forty collieries at work in the Newcastle district, giving details as to acreages, produce, depth of shafts, ventilation, fans, furnaces, haulage, drainage, workmen employed, sections of seams, royalty rents, shipping facilities, &c., &c.

The district price paid for hewing the "bore-hole" seam is 4s. 2d. per ton for round, and 1s. 2d. per ton for slack; and where there is an unusual amount of "chitter" (band) an extra price of 3d. per ton or more is given. Day men, such as labourers, &c., are paid from 7s. to 10s per day of 8½ hours; wheelers, underground, 5s and upwards per day of 8½ hours. Pits commence winding at 7 a.m., and cease at 4 p.m., with a halt of ½-hour for breakfast and ½-hour for dinner.

The report is accompanied by a number of valuable maps, geological plans, and sections, &c., together with plans of royalties attached to collieries.

M. W. B.

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## GRISOUTITE.

*Ueber Welter-dynamite und Sicherheitspatronen. By* JOHANN MEYER. *Oesterreichische Zeitschrift für Berg- und Hütten-wesen, 1889, Vol. XXXVII. pp. 111-113, 123-125, 137-139, 152-156, 161-163, and 171 to 176.*

The first variety of this explosive consisted of a mixture of gelatine-dynamite and crystallised soda, but its use was shortly abandoned, as it was only ignited with difficulty. The next composition was nitro-glycerine 52 parts, kieselguhr

14 parts, and soda 34 parts. 308 grains of this mixture in the lead cylinder produced 3·5 cubic inches of gases, while gelatine-dynamite No. II gave 4·6 to 4·9 cubic inches, and dynamite No. II gave 2·5 to 2·75 cubic inches. Soda grisoutite, therefore, comes in between dynamites II and III as regards power.

Carbonate of ammonium was then tried in place of the soda, and found unsatisfactory, as it readily decomposed. The next substance tried was chloride of ammonium. Three types were made :—

| | I. | II. | III. |
|---|---|---|---|
| Nitro-glycerine ... | 60 | 50 | 40 |
| Chloride of ammonium | 40 | 50 | 60 |

The fumes of these mixtures are very unpleasant. No. I gave 5·8 cubic inches when fired in the lead cylinder.

Epsom salt, or sulphate of magnesium, was then tried, but the mixture proved less safe and stable than soda grisoutite.

Other mixtures were tried as under :—

| | I. | II. | III. | IV. |
|---|---|---|---|---|
| Nitro-benzol-gelatine ... | 30 | 42 | 50 | 50 |
| Nitrate of ammonium ... | 40 | 58 | — | — |
| Sulphate of ammonium ... | 30 | — | 50 | — |
| Sulphate of magnesia ... | — | — | — | 50 |

No. I gave 4·9 cubic inches of gases, No. II 8·6 cubic inches, No. III 3·7 cubic inches, and No. IV 3·1 cubic inches when 308 grains were fired in the lead cylinder. A mixture of nitro-benzol and nitro-glycerine gave from 4·9 to 7·4 cubic inches when 308 grains were fired.

The results of a large number of experiments at the Ferdinand Nordbahn Colliery are recorded.

Soda grisoutite was better than all the other varieties tried, even dangerous coal-dusts were not ignited, and where the charge did not exceed 5·3 ounces, mixtures containing 9 per cent. of gas were not ignited, with and without coal-dust.

M. W. B.

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## SYSTEMS OF FIRING SHOTS.

*Ueber einige Zündmethoden fur Schlagwettergruben and die Joh. Lauer'sche Frictions-Zündung. By* Johann Meyer. *Oesterreichische Zeitschrift für Berg- und Hütten-wesen, 1889. Vol. XXXVII. pp. 47-50, 61-64. and 84-87, with 22 figures.*

Explosions due to blasting in mines are produced either by the fuse or the explosive used, the former being probably the most frequent and dangerous cause.

The use of an ordinary fuse is certainly accompanied with danger, as the time occupied before the flame reaches the shot may allow a dangerous mixture to form.

The use of electric shot-firers is deprecated, and the other methods which have been proposed are described in two classes (*a*) in which the fuse is retained, and (*b*) in which the use of the ordinary fuse is abolished.

Dr. Roths' safety firer consists of a tube (into which the end of the fuse is inserted), containing a flat pellet of a mixture of chloride of potassium sulphide of antimony and sulphur, which is fired by a blow of a weighted needle.

Bickford and Co. sell a safety shot-fire, consisting of a small tube slipped upon the end of the fuse. It contains a small glass bead filled with concentrated sulphuric acid, enclosed in a mixture of chloride of potassium and sugar. It is fired by compressing the tube and fracturing the glass bead.

Müller and Co. are the makers of a small pistol, into whose barrel the end of the fuse is inserted, and fired by means of a pine-fire cap on pulling the trigger.

Lauers' detonator is described in Abstracts, p. 46, Vol. XXXVII. The nature of the explosive used is not mentioned.

Nawratie proposes to fire the shot by means of a pin driven sharply into the detonator by pulling a wire.

Taman and Tirman fire the detonator by the recoil of a hammer impelled by a coiled spring.

Zschokke uses tubes and a ball filled with compressed air. The air in the tubes, either mechanical or chemical. In the mechanical method a needle is driven into the detonator containing fulminate of mercury. In the chemical system, the blast of air blows a little concentrated sulphuric acid, lying in a U-shaped portion of the tube, into the detonator containing a mixture of chloride of potassium and sugar above fulminate of mercury.

The use of fuse is not considered satisfactory, and the correct principle appears to be that by which the ignition is made in the cartridge containing the explosive, either by friction, percussion, or other mechanical or chemical means.

The use of the majority of the methods described involve some danger when employed by unskilled or careless workmen, and finally the Lauer detonator is highly recommended.

With the old Lauer system at the Kaiser Colliery 70,634 shots were fired, with 1,323 miss-fires, or 1·7 per cent., and six accidents by premature explosion of the detonator in nine months. The improved system has been used for about four months—12,304 shots being fired, with 24 miss-fires, and no accidents.

M. W. B.

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## GUIBAL FAN WITH CONICAL INLET.

*Guibal'scher Ventilator mit Einlauf-Conusen.* *By* A. Kas. *Oesterreichische Zeitschrift für Berg- und Hütten-wesen*, 1888, *Vol. XXXVI. pp.* 671-3.

At the Heintz Colliery, near Saarbruck, there is a Guibal Ventilator 36 feet diameter and 9 feet 10 inches wide, fitted at both sides with conical inlets.

The two side inlets have an area of 53·07 square feet, into which the air is drawn in a circular manner.

| No. of Experiment. | Revolutions per minute. | Water gauge in inches. | Volume of air in cubic feet per minute. | Useful effect in air in horse-power. | Indicated horse-power of Engine. | Efficiency. |
|---|---|---|---|---|---|---|
| 1 | 26·25 | ·787 | 76,300 | 9·46 | 13·51 | ·70 |
| 2 | 31·60 | 1·181 | 82,710 | 15·39 | 25·35 | ·61 |
| 3 | 36·10 | 1·437 | 90,580 | 20·51 | 29·59 | ·69 |
| 4 | 39·40 | 1·772 | 101,300 | 28·30 | 43·20 | ·66 |
| 5 | 45·90 | 2·362 | 117,660 | 43·79 | 66·77 | ·66 |
| 6 | 50·50 | 2·890 | 128,000 | 58·28 | 88·48 | ·66 |

M. W. B.

## SECURITE.

*Sekurit. Jahrbuch für das Berg- und Hütten-wesen im Königreiche Sachsen auf das Jahr 1888. Part II. p. 107.*

Experiments made at the Himmelfahrt Colliery showed that for a length of about one yard 12·1 pounds of securite were used to do the same work as 11·1 pounds of dynamite. It was found that dynamite was unaffected by water, whilst securite could not be exploded after lying in water for a few days.

M. W. B.

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## ROCK PRESSURE.

*Vorrichtung zur Messung des Gebirgsdruckes. Zeitschrift für das Berg- Hütten- und Salinen Wesen im Preussischen Staate, 1888. Vol. XXXVI. pp. 244-5, and 1 figure.*

At the Stassfurt salt mine a contrivance has been placed to measure vertical movements of the strata. Wooden plugs about 3 feet long are driven into two vertical holes in the floor and roof of a galley driven in the mineral salt. Two wrought-iron tubes fitted together by means of a pin fitting into the lower tube and sliding into the upper tube, are firmly attached to the wooden plugs.

A vertical board is attached to the side of the place, and clear of the roof and floor. Attached to this board are two levers whose short arms are attached to each of the two tubes, and whose longer arms are used as pointers and move over a scale divided into inches. The lengths of the arms of the levers are as 1 to 10, so that a movement of one inch appears as 10 inches on the scale.

In one case from May 23, 1886, to June 4, 1887, a little more than a year, the upper lever moved 3·44 inches, and the lower lever 4·43 inches, corresponding to a fall of ·344 inch of the roof, and a rise of the thill of ·443 inch. In a second trial from April 24, 1886, to June 4, 1887, the roof came down 1·02 inches, and the bottom rose ·04 inch.

M. W. B.

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## COAL IN SERVIA.

*Steinkohlen-Bergbau ander hohen Cuka bei Zajecar in Serbien. By* A. Gotting. *Oesterreichische Zeitschrift für Berg- und Hütten-wesen, 1888. Vol. XXXVI. pp. 664-*.

The Servian coal-field, in the vicinity of the Bulgarian frontier, is being energetically developed.

The mines are situated in the Teniok Valley, near the town of Zajecar, and are connected with the Danube by a railway about 50 miles in length.

The coal seams are found in the Upper Lias formation, at high inclinations, and much faulted. Only one seam is being worked, with a mean thickness of 20 feet and a maximum of 40 feet.

An area has been proved containing 848,000 tons of coal. The coal is made into briquettes for sale.

M. W. B.

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## PETROLEUM AND NATURAL GAS IN NEW YORK STATE.

*By* Charles A. Ashburner. *Transactions of the American Institute of Mining Engineers, Vol. XVI. 1887, pp. 906-958, and III Plates.*

The existence of the first oil spring was recognised in 1627, and natural gas was first utilised at Fredonia in 1821.

This paper forms a record of the explorations which have been made up to 1887 for oil and gas in the State of New York, and is divided into the following chapters:—Introduction; early references to oil and gas; general geological considerations, with a chart showing the divisions and prominent thicknesses of the rocks of the Palaeozoic system in New York, Pennsylvania, and Ohio; geological map of portions of New York and Pennsylvania; conditions attending the occurrence of natural gas; general sections showing the relative positions of the petroleum and natural gas sands; popular plans of explorations; the Fredonia gas wells; composition of Fredonia gas; William's conclusions for Western New York; the Buffalo gas wells; oil and gas in Alleghany County (New York), with map; oil and gas sands of Pennsylvania; largest producing gas well in New York; explorations for gas in Central New York; natural gas in Ontario county; explorations for gas in Albany county; geological section of the Catskill mountain range; explorations for gas in Greene county; and scattered explorations for gas.

M. W. B.

## WAGES IN PRUSSIAN MINES.

*Die Arbeitslohne beim Preussischen Bergbau. Glückauf, Vol. XXIV. 1888, pp. 690-1.*

| Districts. | Underground. | | | | Surface. | | | | | | | | All Classes. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Miners. | | Other Workmen. | | Workmen. | | Boys from 14 to 16. | | Women. | | | | | |
| | Per Day | Per Annum | Per Day | Per Annum | Per Day | Per Annum | Per Day | Per Annum | Per Day | Per Annum | | | Per Day | Per Annum |
| | s. d. | £ s. d. | s. d. | £ s. d. | s. d. | £ s. d. | s. d. | £ s. d. | s. d. | £ s. d. | | | s. d. | £ s. d. |
| Upper Silesia, coal | 2 0½ | 26 17 0 | 1 11 | 27 2 0 | 1 7 | 22 12 0 | 0 8½ | 9 3 0 | 0 9 | 10 6 0 | | | 1 9¾ | 24 12 0 |
| Lower Silesia, coal | ? | ? | ? | ? | ? | ? | ? | ? | 1 1¼ | 16 15 0 | | | 2 1¾ | 31 6 0 |
| Halle, lignite ... | ? | ? | ? | ? | ? | ? | ? | ? | 1 3¼ | 16 11 0 | | | 2 1¾ | 31 8 0 |
| Halle, copper ... | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | | | 2 5 | 35 0 0 |
| Halle, salt... ... | 3 1 | 46 4 0 | 3 4½ | 53 6 0 | 2 11 | 46 12 0 | 1 2 | 18 2 0 | 1 1½ | 19 17 | | | 3 0 | 46 0 0 |
| Harz ... ... | ? | ? | ? | ? | 1 6 | 23 2 0 | 0 7½ | 9 4 0 | — | — | | | 1 11⅜ | 29 8 0 |
| Dortmund, coal ... | 2 9¼ | 44 6 0 | ? | ? | 2 4½ | 38 12 0 | ? | ? | ? | ? | | | 2 6¾ | 39 16 0 |
| Saarbruck, coal ... | 3 0 | 42 17 0 | 2 7 | 36 14 0 | 2 6½ | 34 18 0 | 1 3 | 17 13 0 | ? | ? | | | 2 10¼ | 40 14 0 |

M. W. B.

## PLOM AND D'ANDRIMONT'S SYSTEM OF BLASTING.

*Das Sprengverfahren von Plom und d'Andrimont. By* W. Schulz. *Glückauf, Vol. XXIV.* 1888, *pp. 249-251, 257-258, and 7 figures.*

Messrs. Plom and d'Andrimont appear to have solved the problem of a means of forming an enlarged cavity for the powder at the end of a hole for blasting.

The chambering tool consists of a hollow iron tube, fitted with a screw, to the end of which a pair of blades are hinged.

After a hole has been bored in the ordinary way to the required depth, and about 1¾ inches in diameter, the chambering tool is inserted in the hole, and turned by means of a ratchet handle, the blades are pressed outwards as required, until the chamber is completed.

The coal, which is reduced to a fine powder by the rotation of the blades, falls into slots in the sides of the tube, and is gradually moved along the tube by the action of the screw, until it falls out at the end.

The gunpowder is placed in the chambered end of the hole by means of a copper tube, fitted with longitudinal slits, through which the powder is pushed by a wooden rammer. The stemming consists of a slightly tapered wooden plug with the fuse attached. The plug is about 14 inches long, with a longitudinal slot and hole through its middle, through which the fuse is knotted and laid along the longitudinal slot. The plug is pushed to the end of the hole, and the clay stemming inserted.

The following experiments have been made in a hard seam about 4 feet thick :—

| | By the Ordinary System. £ s. d. | | By Plom and d'Andrimont's System. £ s. d. |
|---|---|---|---|
| Price per 10 wagons of ·49 tons ... ... | 0 4 0 | ... | 0 2 5 |
| Wages only ... ... ... ... ... | 6 4 5 | ... | 7 1 6 |
| Powder ... ... ... ... ... ... | 0 1 3 | ... | 0 16 9 |
| Carriage of coal to inclined plane (wages 2s. 1d. per shift) ... ... ... ... | 1 9 1 | ... | 1 9 2 |
| Total cost ... ... | £7 14 9 | ... | £9 7 5 |
| Coal produced (including rubbish) ... ... | 156 tons. | ... | 281 tons. |
| Cost of coal produced per ton ... ... | 11·9d. | ... | 8·0d. |
| Number of shifts ... ... ... ... | 51½ | ... | 41½ |

M. W. B.

## MANGANESE IN BOSNIA.

*Ueber den Manganerzbergbau Cevljanovic in Bosnien. By* F. Poech. *Oesterreichische Zeitschrift für Berg- und Hütten-wesen*, 1888. *Vol. XXXVI. pp.* 253-255, 267-268.

The manganese ore is found at the Cevljanovic Mine, situated about 12 miles north of Serajevo. The deposit lies between sandstone and limestone for hanging and footwalls, and consists of

| | | | | |
|---|---|---|---|---|
| 45 | to | 50 | per cent. of | Manganese. |
| 6 | to | 14 | do. | Silica. |
| ·02 | to | ·1 | do. | Phosphorus. |
| ·02 | to | ·05 | do. | Sulphur. |
| 3 | to | 7 | do. | Iron. |

The ore is suitable for the manufacture of ferro-manganese, and about 5,000 tons are exported annually to England. M. W. B.

## FIRING OF SHOTS.

*Pistole zum Anbrennen von Zündhütchen. Berg- und Huetten-maunnischee Zeitung. Vol. XLVIII.* 1889, *p.* 206.

The pistol consists of a metallic gauze cage containing a guiding pipe, in the position of the barrel, together with a box into which an ordinary gun-cap is placed. It is fitted with a hammer, trigger, and handle, in the ordinary way. The fuse is placed in the central guiding pipe or barrel lead to the gun-cap, and then the pistol is fired by a length of string. All flame (or sparks) is confined within the wire-gauze. M. W. B.

## WEIGHT PER CUBIC FOOT OF ANTHRACITE COAL BROKEN TO MARKET SIZES.

*By* J. W. Bowden. *The Engineering and Mining Journal (New York), Vol. XLVII. 1889, pp. 496-7.*

| Susquehanna Coal Company. | Specific Gravity. | Weight in Pounds per Cubic Foot of Solid Coal. |
|---|---|---|
| Mills Seam | 1·4520 | 90·46 |
| Hillman Seam | 1·4673 | 91·41 |
| Forge Seam | 1·4820 | 92·32 |
| Twin Seam | 1·4800 | 92·20 |
| Buck Mountain Seam | 1·5210 | 94·75 |
| General average | 1·4784 | 92·10 |

| Size of Coal. | Size of Mesh. | | Weight in Pounds per Cubic Foot of Broken Coal. | No. of Cubic Feet of Broken Coal from one Cubic Foot of Solid Coal. |
|---|---|---|---|---|
| | Over. | Through. | | |
| | Inches. | Inches. | | |
| Lump | $4\frac{1}{2}$ to 9 | — | 57 | 1·614 |
| Broken | $2\frac{3}{8}$ to $2\frac{7}{8}$ | $3\frac{1}{4}$ to $4\frac{1}{2}$ | 53 | 1·737 |
| Egg | $1\frac{3}{4}$ to $2\frac{1}{4}$ | $2\frac{3}{8}$ to $2\frac{7}{8}$ | 52 | 1·769 |
| Large Store | $1\frac{1}{4}$ to $1\frac{7}{8}$ | $1\frac{3}{4}$ to $2\frac{1}{4}$ | $51\frac{1}{2}$ | 1·787 |
| Small Store | 1 to $1\frac{1}{4}$ | $1\frac{1}{4}$ to $1\frac{1}{2}$ | $51\frac{1}{4}$ | 1·795 |
| Chestnut | $\frac{5}{8}$ to $\frac{3}{4}$ | 1 to $1\frac{1}{4}$ | 51 | 1·804 |
| Pea | $\frac{3}{8}$ to $\frac{5}{8}$ | $\frac{5}{8}$ to $\frac{7}{8}$ | $50\frac{3}{4}$ | 1·813 |
| No. 1 Buckwheat | $\frac{3}{16}$ to $\frac{3}{8}$ | $\frac{3}{8}$ to $\frac{5}{8}$ | $50\frac{3}{4}$ | 1·813 |
| No. 2 Buckwheat | — | $\frac{3}{16}$ to $\frac{3}{8}$ | $50\frac{3}{4}$ | 1·813 |

M. W. B.

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## THE JEFFREY ELECTRIC COAL MINING MACHINE.

*The Engineering and Mining Journal (New York)*, 1889. *Vol. XLVIII. p.* 4, *and* 1 *figure.*

This coal-mining machine consists of a bed-frame 2 feet wide and $7\frac{1}{2}$ feet long, composed of two steel channel bars firmly braced together, the top plates, one each, being racks with the teeth downwards, into which the feed wheels of the sliding-frame engage. The sliding-frame is mounted upon the bed-frame, and consists of two steel T-bars, upon the rear end of which an electric motor is fixed ;

suitable gearing is provided by which the sliding-frame can be fed forward or backward from the motor. The cutter-bar is mounted on the front end of the sliding-frame upon suitable brass-lined bearings. The cutter-bar is cylindrical, and suitably slotted to carry 12 steel chisels or cutters, held in place by set screws. These chisels cover the entire face of the cutter-bar when it is revolved. The cutter-bar is driven by an endless steel chain from the driving shaft of the motor, and as it is revolved it is advanced, by the gearing, into the coal or other material to be under-cut to the desired depth. The feed is thrown on or off by an automatic lever.

The machine will cut under the coal to a depth of 6 feet by 3 feet wide and 4 inches high in from 3¼ to 5 minutes, and the withdrawal is effected in from 4 to 6 minutes. At this rate, it will under-cut from 600 to 1,000 square feet per day of 10 hours. The machine can be handled by two men, and will under-cut in either coal or fire-clay.

The motor is driven by a current of 60 ampères, at a pressure of 200 volts, or say 16 electrical horse-power. M. W. B.

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## APPARATUS FOR DETECTING THE PRESENCE OF NOXIOUS GASES.

*Vorrichtung zum Anzeigen schädlicher Gase. By* Paul Binsfeld *and* Gustav D. Orville. *Berg- und Huetten-mœnnische Zeitung. Vol. XLVIII.* 1889, *p.* 83.

The apparatus consists of a closed circular-shaped porous earthenware tube, one of whose ends is left free. The presence of gases is indicated by the diffusion into the tube, which tends to straighten the tube. The end of the tube is arranged so as to make an electric contact, when any desired proportion of gas is present. In another form a spiral of metal tubing is employed, connected with a drum covered with a porous earthenware cover.

The apparatus is contained in a small box, fitted with two binding screws, so that the results may be recorded at any distance. M. W. B.

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## OZOKERITE.

*Mineral Wax. The Engineering and Mining Journal (New York),* 1889, *Vol. XLVIII. pp.* 8 *and* 9.

Ozokerite, ceresin, or mineral or earth-wax, is found in small quantities in Great Britain (at Binnie quarries in Linlithgowshire, Urpeth Collieries in the County of Durham, and in Wales), in Moldavia, and Croatia (near Agram). But the most important deposits are in Galicia (at Boryslaw, Truskawiec, Dwiniacz and Starunia), and in the United States (near Los Angeles in California, in Texas, and near Pleasant Valley Junction, and Soldiers' Summit in Utah).

A description of the Galician deposits is found on page of the Abstracts in the present volume.

The deposits of Utah cover an area of eight miles long and 1½ miles broad on the White River. There are several deposits of the wax exposed on the surface, and, while thin at the outcrop, they increase in thickness with depth. The deposits are at present worked by open cuts or shafts. It is considered to be an evolved deposit, resulting from the distillation of beds of Cretaceous lignite or the residues of a petroleum unusually rich in paraffin.

| | Melting Point. | Boiling Point. | Composition. Hydrogen. | Nitrogen. | Total. |
|---|---|---|---|---|---|
| Galician ... | 140° to 145° F. ... | — .. | — ... | — ... | — |
| Moldavian | 144° ... | 410° ... | 86·20 ... | 13·77 ... | 99·97 |
| Do. ... | 183° ... | 572° ... | 85·75 ... | 15·15 .. | 100·90 |
| Slanik ... | 144° ... | — ... | — ... | — ... | — |
| Urpeth ... | 140° ... | 251° ... | 86·80 ... | 14·06 ... | 100·80 |
| Utah .. | 143° ... | 572° to 716° ... | 86·15 ... | 13·75 ... | 99·90 |

It is largely used in the manufacture of candles, for insulating electrical wires for underground and line uses, in electrotyping and stereotyping, and in etching on steel plates. It is used to impart lustre to shoe blacking, and in the manufacture of sealing wax, liniments, salves, plasters, matches, varnishes, wax figures, shoemakers' wax, etc. It is mixed with oil to form a lubricant for rapid running machinery, it is recommended as the base of a cheap composite paving material, for indurating piles and posts to prevent decay, and it is applied to waterproof paper for wrapping soaps, metals, books, and all articles requiring protection from moisture It is used as an adulterant of beeswax, and to protect boxes, tubs, barrels, &c., and such when lined with it become watertight, as the wax fills the pores of the wood and gives no odour to the contents. The most recent application is in coating the cylinders upon which the graphophone stylus traces its record.

M. W. B.

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## COAL IN MADAGASCAR.

*Terrains houillers de Madagascar. By* MM. RIGAUD *and* GUINARD. *Le Génie Civil*, 1889. *Vol. XIV. pp.* 248-249, *and* 1 *figure.*

On the north-west coast of Madagascar, the strata consist of :—

*Permian.*—Its southern limit is a basaltic dyke, running N. 20° W. from the coast west of Raminitoe Bay. The chief rocks are red sandstones, and a few interbedded reddish argillaceous shales, and extend along the coast northwards to the Antsoha Island. The true Coal Measures are found in this area at the entrance, and on the south side of Baramahamay Bay, several places near Andransamonta, and on the banks of the Manambary River near the port of Radama.

*Coal Measures.*—Commence on the northern limit of the Permian, where the latter is cut off by a large fault. The coal-field extends northwards, and is easily recognised on the coast as far as the north-west point of Ambato Bay. The Coal Measures, whose successive beds are superimposed in going from the south to the north, have a dip varying from north-west to north-east, except where locally deranged. They consist of a series of siliceous sandstones, from white to grey or red in colour ; of leafy shales varying from grey to black ; and lastly of beds of hard white, grey or black sandstones.

Thin seams of coal are found throughout the entire region, but chiefly in Baratobe Bay, and on the river Jangoa. The beds vary from 1 to 3 inches in thickness, some are of little area, whilst others form irregular beds with continuity in direction or depth.

*Permian.*—These rocks reappear on the north of the Coal Measures, upon which they appear to lie conformably, in order of deposition. The Permian commences to the south of the limit assigned to the Coal Measures, but it only appears at some distance from the coast, along which there are bands of Coal Measures. The southern limit of this Permian area commences in the mountains forming the south bank of the River Sambirano, and separating it from the River Jangoa. These

measures extend for about 28 miles south or south-east up the Sambirano, and 19 miles up the Ampampamene River, near the Ambato bay. The rocks consist of beds of sandstone, not so red, but much thicker than the Permian lying to the south. Fine white sandstones are found interbedded.

True Coal Measures are found in this area, in the plains of the Sambirano, upon a hill running west to east on the south bank of the river, and about 12 miles from its mouth; and at a point 27 miles up the same river, where it passes between two hills. This and the southern areas of Permian rocks are barren of coal.

The Coal Measures are practically barren, and contain nothing which merits the name of a coal-bed, or which might justify further researches. M. W. B.

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## PUMP WITH "CAPTANT" PISTON.

*Pompe à Piston captant.* *By* J. Mareschal. *Le Génie Civil. Vol. XII.* 1888 *pp.* 388-389, 3 *figures.*

In this pump, invented by M. S. de Montrichard, all valves are suppressed whilst an alternate motion of the piston is maintained, and also the rotary motion. The piston, which is a novel part of the system, is of helicoidal form. It is fixed upon an axis which, passing through bearings and stuffing-boxes, traverses a cylindrical pump closed at the ends. Two friction guide wheels are placed at the top (and inside) of the pump cylinder, and press upon the oblique faces of the piston. Consequently, when the piston is rotated on its axis, it is driven backwards and forwards, which creates on each of its sides in succession—an exhaustion and a compression.

Inlet and exhaust pipes are placed upon the pump cylinder, close to the guide wheels. There is at all times compression on the side to which the piston advances, and exhaustion on the other side, consequently so long as the direction of rotation is unchanged, the flow of fluid is always in the same direction It may be remarked that the current is produced in one direction or another, according to the direction of rotation; this property may be utilised, as a vessel may be filled by running in one direction, and emptied by running in the other direction.

A pump of 8 inches diameter, running 100 revolutions per minute, exhausted 10,500 gallons per hour; another of 10 inches diameter exhausts 19,500 gallons per hour, at 90 revolutions per minute. M. W. B.

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## WIRE ROPE HAULAGE AND ITS APPLICATION TO MINING.

*By* Frank C. Roberts. *Transactions of the American Institute of Mining Engineers,* 1887-8, *Vol. XVI. pp.* 213-257, *and* 45 *figures.*

The various adaptations of wire rope employed in placing or conveying coal and ores upon the surface are considered in the following order :—

Hoists.
Inclined planes.—Engine planes.
Gravity planes.
Aerial planes.
Haulage.—Tail rope system.
Counter rope system.
Endless rope system. M. W. B.

## THE CONSTRUCTION OF MAPS IN RELIEF.

*By* John H. Harden *and* Edward B. Harden. *Transactions of the American Institute of Mining Engineers*, 1887-8, *Vol. XVI. pp.* 279-301, *and* 10 *figures.*

Relief maps reduce problems in engineering science and geological structure to a simple and understandable form, and afford a ready means of imparting clear and accurate knowledge of topography, &c.

The various modes of constructing relief maps are described in detail: by section lines, parallel and at right angles on thin strips, by pins, by sheets of card board cut to contour lines, carving out of wood or plaster blocks, by vertical strips following the line of contour, &c. M. W. B.

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## MODES OF OCCURRENCE OF PYRITES IN BITUMINOUS COAL.

*By* Amos P. Brown. *Transactions of the American Institute of Mining Engineers*, 1887-8. *Vol. XVI. pp. 539-546.*

Pyrites, the bisulphide of iron, $FeS_2$, is found more or less in coal seams in the following well-marked forms :—

In nodules or lenticular masses ;

In defined and persistent stratified bands ;

In thin flakes and "knife edges" parallel to the bedding of the coal ;

In coatings or crusts, lining joints or cavities in the coal ; and

In fine rounded particles, scattered through the substance of the coal.

M. W. B.

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## A SIMPLE WATER LEVEL.

*By* P. Kahle. *Zeitschrift für Vermessungswesen*, 1888, *p.* 183.

A strong glass tube, about ½-inch diameter and 24 inches long, is bent into the form of a rectangle 8 inches long and 4 inches broad, and is half filled with coloured alcohol before the ends are fused together. In use the instrument is held in the hand, and the eye of the observer placed on the level of the surface of the liquid in two of the parallel arms, gives the reading upon the staff.

Over a length of about 10,000 feet, and a vertical height of 743·1 feet, accurately levelled, with the instrument, a difference of level of 744·7 feet was obtained, an error of only 1·6 feet. A similar instrument is described on pp. 128 and 129 of Vol. XXVI. of the Transactions. M. W. B.

# INDEX TO VOL. XXXVIII.

NOTE.—The dash (—) at the beginning of a line denotes the repetition of a word; in case of Names, it includes both Christian Name and Surname.

"Abs." signifies Abstracts of Foreign Papers at end of the Proceedings.

Discussions and local names of coal-seams and other strata are denoted by italics.


Above-ground arrangements at Warora, 104.
Accidents in mines, 30.
— at Warora, 133-137.
Accounts, viii.
ADAMS, MESSRS. BROWN and, quoted, 89.
Address by the President, Mr. J. MARLEY, 29-46.
Advertisement, 0.
Africa (South) diamond mines, 72.
Agasi, 81.
Aikona, 80.
Air compressing machinery, the danger attending the use of light mineral oils for lubricating, 3-12.
Air currents in mines, an account of experiments on the resistance of, 205-216.—Discussion, 216-218.
Air-feed drill, the Jeffrey, abs. 23.
Air, moisture of, in mines, abs. 34.
Alaska, cannel coal in, abs. 19.
Almaden (New), the quicksilver mines of, abs. 8.
—, mines and works of, abs. 53.
Alsace, 62, 63, 69.
Alte-Hoffnung mine at Schönborn, 64.
Alter deutscher wilder Mann mine, 64.
American borings, abs. 45.
Analysis of Indian coals, 82, 85, 90.
— — — iron ores, 166.
— — — limestones, 167.
Anterjaon, 82.
Aouli (phyllanthus emblica), 130.
ARMSTRONG, LORD, quoted, 29, 32.
ARMSTRONG, W., JUN., on the economical working of steam boilers at collieries.
— discussion, 223-228.
— quoted, 44.
Artesian wells in Saxony, abs. 13.
ASHBURNER, CHAS. A., petroleum and natural gas in New York State, abs. 64.
Ashbury Railway Carriage Builders, 110.
Assam Railway and Trading Company, 158.
Assensol, 161.
ATKINSON, W. N., *exhibition of safety lamp*, 18.
— quoted, 177.
— *use of light mineral oils*, 10, 11.
Associate Members, xxxi.
Associates, xxxi.
Austria, Hallstadt, 62.
AYRTON, PROF., quoted, 37.

BABU, L., ozokerite and petroleum in Galicia, abs. 15.
— the Rammelsberg mine (Hartz), abs. 28.
Bahera (terminalia bellerica), 131.
Bailgaum, 80.
Balks, 55.
Bandur, 169.
Bandar coal-field, 80.
Barakar coal, value of, 161.
— group, 92.
Barakars, 78, 79.

Barba, A. A., quoted, 65.
Barberton, 171.
Bar channeler, the Saunders, abs. 20.
Barnes, Amos, quoted, 189.
Barometer readings, 229-235.
Barras Bridge, 192.
Barth Carl, the Fohnsdorf coal-field, (Styria), abs. 50.
Basalt, 99.
Bauer, Max, natural ferric sulphates in Chile, abs. 2.
*Beaumont seam*, 53, 196, 197.
Beck, Rich., artesian wells in Saxony, abs. 13.
Bedson, Prof., *outbursts of gas in metalliferous mines*, 70.
— quoted, 4, 10, 36.
— *use of light mineral oils*, 7, 8, 9.
Beer wire rope way, abs. 23.
Belgium, statistics of mining, 1884 and 1885, abs. 57.
Bell, Jno., quoted, 190.
Bell, Sir Lowthian, quoted, 30, 39, 42.
Bell, T., *coal mining at Warora, East India*, 170.
— *notes on variation in faulting of coal*, 55-57.
— *outbursts of gas in metalliferous mines*, 71, 72.
— *the Pieler spirit lamp*, 182*a*, 182*b*.
Bell, Walter, nominated, 219.
Belmez-Espiel coal-field (Spain), abs. 55.
Belmont, 55.
— Grange, 55.
Beluchistan, 158.
Benares, 116.
Bengal, 78.
— Barakar coal, value of, 161.
— coal, 160.
— Kurhurbaree coal, value of, 161.
Bengal-Nagpore railway, 139, 155-158, 169.
Bengal (Northern) railway, 160.
Benson, T. W., *alteration of bye-laws*, 76*b*.
—, *notes on variation in faulting of coal*, 53.
Benwell colliery, 53.
Benzine lamps in coal mines, abs. 4.
Berar, 81.
Berars, The, 83.
Berkley, —, *the Pieler spirit lamp*, 182.
Bex salt mines, 61.
Bhavnagar railway, 157, 162.
Bhirra, or satinwood (chloroxylon swietenia), 131.
Bilbao iron ore deposits, abs. 18.
— mines of, abs. 25, 26.
Binsfeld, Paul, apparatus for detecting noxious gases, abs. 68.
Bird, W. J., notes on Seaton Carew boring, 21.—Boring section, 21.—Notes on boring section, 24.—Abstract of boring section, 25.
— on the economical working of steam boilers at collieries.—Discussion, 223-228.
—, quoted, 39.
Bishop, James, election, 75.
Bitumen, 61.
Bituminous coal, pyrites in, abs 71.
Blackett, W. C., scrutineer, 219.
— *the Pieler spirit lamp*, 182, 182*a*.
Blagburn, Charles, election, 75.
Blair furnace, 165.
Blasting, Plom and D'Andrimont system, abs. 65.
Boiler explosions, 35.
— explosion at Friedenshütte, abs. 25.
Boilers, water for, abs. 60.
—, economical working of, 233, 228.
Boinski, H. Z., geology of the Lower Congo, abs. 54.
Bombay, Baroda, and Central Indian railway, 157, 160, 161.
— price of coals at, 160.
Borehole at Salter's Bridge, 189.
— *seam*, 16.
Boring machine (the Fröhlich) abs. 41.
— at Schladebach, abs. 1.
— cost of, in India, 93-97.
— section at Seaton Carew, 21-25.
Borings, American, abs. 45.
Bosnia, manganese in, abs. 66.
Boty safety lamp, abs. 38.

Boty safety lamp, height of cap, 181.
Bowden, J. W., weight per cubic foot of anthracite coal, abs. 67.
Bower and Co.'s electrical coal-cutting machine, 32.
Boyd, E. F., quoted, 41, 42.
Brahmins, 116.
Braive, M., grisoutite, carbonite, and dynamite, abs. 26.
Bramwell, Sir F., quoted, 45.
Brandling, John, 191.
Brandling, Rev. R. H., 198.
Brandling, R. W., 198.
Brandling, W., quoted, 195.
Bray, —., quoted, 172.
Bremer, J. M., quoted, 61.
Briquettes, manufacture of,in Italy, abs. 24.
Brittany, Pontpéan, 63.
British Association, Newcastle meeting, 47, 220.
*Brockwell seam*, 49, 50, 52, 53, 56, 57.
Broockmann, Dr. K., quoted, 179.
Broomside, 55.
Brough, Bennett H., outbursts of gas in metalliferous mines, 59-70.
Brown, Amos, modes of occurrence of pyrites in bituminous coal, abs. 71.
Brown and Adams, Messrs., quoted, 89.
Brown, M. Walton, *air currents in mines*, 216, 218.
— *alteration of bye-laws*, 184, 185.
— barometer and thermometer readings, 229-235.
—*exhibition of safety lamp*, 18.
— quoted, 39.
— scrutineer, 219.
— the Pieler spirit lamp, 177-181.
— *use of light mineral oils*, 9, 10, 12.
Brown, Thomas, election, 75.
Brunton, 195.
Buddle, J., quoted, 39, 42, 53.
Budnera Mill Company, 139, 155.
Bunning, C. Z., coal mining at Warora, 77-169.
Bunning, T. W., quoted, 43, 220.
Bunsen, Prof., quoted, 69.
Burls, Herbert Thomas, election, 47.
Burma Railway, 157.
— (Upper) coal, 158.
Burn, Frank Hawthorne, election, 47.
Burwood Colliery, 15.
*Busty seam*, 49, 50, 51, 52, 56, 57.
Bye-laws, xl.
— alteration of, iii., 76*a*, 183-185.

Cages, Klinik safety-catch for, abs. 16.
California, the quicksilver deposits of New Almaden, abs. 8.
Cameron's pump, 16.
Cannel coal in Alaska, abs. 19.
Capell ventilating fan, abs. 9.
Captant piston, abs. 70.
Carbonic oxide gas, abs. 55.
Carboniferous rocks, 72, 78.
Carbonite, abs. 26.
Carn Bora mine, Cornwall, 10.
Carr, John Evelyn, nomination, 76 election, 187.
Carr disintegrator, 85.
Carroll, Philip, the sulphur mines of Sicily, abs. 50.
Casebourne, C. T., Seaton Carew boring, 21.
Casella air meter, 206.
Cassop, 55.
Castel,— quoted, 62.
Castle Eden, 55.
Cements, permeability of, abs. 21.
Centrifugal blower, abs. 48.
Chamars, 116.
Chanda, 77, 80, 82, 84, 130, 153, 168, 169.
Chapman, A. C., election, 1.
Charlon, —, 63.
Charles Pit—Flaggy Creek pit heading: description of the survey, 13.—Ventilation of heading, 15. — General description of colliery, 15.
Charter, xxxvi.
Chattisgarh, 77.
Chemistry (applied), Richardson and Watts' dictionary on, quoted, 70.
Cherra Company's Ganj railway, 158.
— Poonjee, 158.

Chettris, 116.
Chicholi, 81.
Chichwa (albizzia odoratissima), 131.
Chicken, Lancelot Wilkinson, nomination, 76 ; election, 187.
Chile, natural ferric sulphates in, abs. 2.
Chimmur, 80.
Clanny lamp, 37.
Claughton, Geo., quoted, 189.
Cleator, 70.
Cleveland mines, 71.
Churprinz Friedrich August mine, at Gross-Schirma, 64.
Coal (anthracite) weight, &c., abs. 67.
— (bituminous) pyrites in, abs. 71.
— (cannel) in Alaska, abs. 19.
— comparative value of different kinds, 161.
—, consumption and supply of Indian railways, 157.
Coal-cutting machines, v., 32-34.
— — — (electric), abs. 6.
Coal, distribution of, 155, 161.
Coal-dust, 36.
Coal (English) prices of in India, 160.
— faulting of, 49, 58.
Coal-field, Belmez-Espiel (Spain), abs. 55.
—, Fohnsdorf, abs. 50.
—, Ghugus, 80, 82, 84, 169.
—, Makum, 158.
—, Raniganj, 78, 105, 107.
—, Wardha Valley, 77, 78, 79, 85, 88, 153.
—, (Warora), area of, 153.
—, (Westphalia), the northern portion, abs. 3.
Coal-heading machines, Stanley patent, 158.
Coal (Indian) prices of, 160.
— in Madagascar, abs. 69.
— in Servia, abs. 64.
— mines, benzine lamps in, abs. 4.
— mining machine, electric, abs. 67.
— — industry of Lower Silesia, abs. 17.
— — at Warora, central provinces, East India, 77.—Geological features, 77.—Physical geography, 83.—History, 84.—Coal, 84.—Fire clay, 91.—The superincumbent strata and cost of sinking through them, 92.—Cost of sinking No. 6 pit, 93.—Cost of boring, 93.—Speed of boring, 95.—Comparative cost of hand boring and steam boring, 96.—The underground fire, 97.—The colliery above-ground, 104.—Ventilation, 110.—Underground work, 113.—The system of working the coal, 127.—Cost of timber, 130.—Accidents, 133.—Number of persons employed, 137.—Output of Warora since it was opened out, 138—The selling and getting prices of Warora coal, 138.—Cost of getting and raising, 140.—Earnings and profits, &c., 140.—The cost of working, 143.—Price of labour, 148.—The area and amount of coal at Warora, 153.—The distribution of Warora coal, 155.—Fuel consumption and supply on Indian railways, 157.—Other collieries in India, 158.—Table showing distribution of coal on Indian railways, 161.—Cost at Warora of some of the more important stores, 162.—Rates at Warora for contract work, 164.—Iron ore near Warora, 165.—Conclusion, 168.—Vote of thanks, 169.
Coal, price at Kurachi, 160.
— — at Madras, 160.
— at Warora, amount of, 153.
— washing, settling ponds, abs. 12.
Cochrane, N., election, 27.
Cochrane, Wm., *steam boilers*, 223.
Cohen, E., the Transvaal gold districts, abs. 2.
Coke, cost of, in Italy, abs. 24.
— manufacture of, 40.
— — in Westphalia, abs. 4.
— ovens, 40, 41.
Collieries in India, 158-161.
Colliery warnings, 35.
Comparative value of different kinds of coal used on Indian railways, 161.
Comstock, Pelton high-pressure water wheel and dynamos on the, abs. 20.
Conegliano, Lombardy, 65.
Congo (Lower), geology of, abs. 18, 54.

Construction of maps in relief, abs. 71.
Consumers of Warora coal, 139.
Consumption of coal on Indian railways, 157.
Contents of Vol. XXXVIII., i.
Contract work, rates for, at Warora, 164.
Copper, extraction of, from pyrites, abs. 32.
Corbett, V. W., quoted, 35.
Corea, gold and other mines in, abs. 21.
Corfu, abs. 2.
Cornish beam engines, 108.
Cost of boring in India, 93, 96.
— — fuel on Indian railways, 157, 161.
— — raising coal, Warora, 140-147.
— — sinking a new pit at Gosforth colliery, 191.
— — — at Warora, 92, 93.
— — stores at Warora, 162, 163.
— — timber at Warora, 130.
— — Waddle fan at Warora, 112.
— — working Warora colliery, 143-147.
Cotton mills using Warora coal, 155, 159.
Council report, iii.
Coulthard, Francis, nomination, 75; election, 187.
Cowan and Co , 94.
Coxlodge colliery, 194, 196.
Crawford, William, election, 75.
Crone, S. C., quoted, 35.
— *the winning of the high main coal at Gosforth*, 198, 200, 201.
Cumberland mines, 70.

Daglish, J., *presidential address*, 45, 46.
— quoted, 42.
Dandot colliery, 158.
Darley, Mill Close lead mine at, 59.
Daubree, A., quoted, 62.
Davies, Lieut.-Col. Jasper Gustavus Sylvester, nomination, 187; election, 219.
Davis, Kenneth MacRae, election, 75.
Davy lamp, 37, 71, 177, 181.
Dean pit, Gosforth colliery, 189.
Deccan trap, 78.
De Kaap gold fields, 171.
Delagoa Bay railway, 175.
Delhi, 116.
— railway, 159.
*Denton low low main seam*, 196.
Derbyshire lead mines, 59, 67, 69.
Description of fuel used on Indian railways, 157.
Dewalgaon, 165.
Dhaora (anogeissus latifolia), 130.
Dhers, 116.
Distribution of coal on Indian railways, 161.
— — the internal friction of engines, abs. 36.
— — Warora coal, 155.
Dodds, Ralph, quoted, 195.
Dortmund, &c., mining produce in 1888, abs. 37.
Douglas, T., *alteration of bye-laws*, 183, 185.
Dravidian tribes, 77.
Dressing ore-rolls in position, abs. 12.
Drill, the Jeffrey air-feed, abs. 23.
Dunker, E., boring at Schladebach, abs. 1.
Durham College of Science, xiii., 220,
Dynamite, abs. 26-28.
Dynamos, high-pressure water wheel and, Comstock, abs. 20.

Earl of Sandwich, quoted, 65.
Earnings of Warora colliery, 140.
Earthquakes and fire-damp in mines, abs. 18.
Earth tremors, committee, 43.
— —, abs. 46.
Eastern Bengal railway, 159, 161.
East India, coal mining at Warora, 77-169.
— — railway, 157, 161.
— Indian railway company's colliery, 158.
Easton, James, quoted, 57.
Economical working of steam boilers, discussion, 223-228.
Electrical and other coal-cutting machines, 32-34.

Electric coal-cutting machines, abs. 6.
— — mining machine, abs. 67.
— safety lamp exhibited, 17-19.
Electricity, Murday's apparatus for obtaining readings from indicators at a distance, 71.
—, transmission of power by, abs. 35.
Elliot, Sir Geo., quoted, 31, 36, 42, 43.
Elwen, T. L., election, 1.
— experiments on resistance to air-currents, 205-218.
Embleton, T. W., notes of reports of winning of the high main coal at Gosforth colliery, 189-203.
Empress mill, Nagpore, 139, 155.
Engines, internal friction in, abs. 36.
English coal, prices of, in India, 160.
— patent fuel, value of, 161.
Erzgebirge mines, 67.
Ewes Burn, estimated expense of building a bridge across, 192.
Exhibition, Newcastle-upon-Tyne, abs. 24.
Expense of winnings at Gosforth, 191-193
— (estimated) of working Gosforth colliery, 189-191.
Explosions in salt mines, 61.
Explosive agents, 36.
Explosives, experiments with, abs. 56.
Extraction of copper from pyrites, abs. 32.
Eyam registry, quoted, 60.

Factories Act, Indian, 113, 133.
Fallowfield lead mine, 72.
Falun mine, 66.
Fan experiments committee, v., 43, 220.
Fan (Guibal) with conical inlet, abs. 63.
Fans, 31.
Fan ventilation, observations on, abs. 22.
Farey, J., quoted, 60.
Faulting of coal, 49-50.
Faults, a study of, abs. 56.
Fayre, —., quoted, 104.
Federation of mining institutes, iii., 42, 76-76*a*, 220, 221.
— bye-laws, 76.
Federation of mining institutes, council, elected and co-optated members, iv.
Finance, 43.
— report, vii.
Fineuse —., on water for steam boilers, abs. 60.
Fire-clay, Indian, 91.
Fire-damp in mines, abs. 18.
— indicator, the Pieler spirit lamp, as a abs. 177.
Fires, underground, in India, 97-104.
Firing shots, abs. 62, 66.
First pit, Gosforth, 190.
*Five-quarter seam*, 52, 53, 55.
Flaggy creek pit heading, 13.
Flameless explosives committee, v., 43, 220.
Fleming, Charles Edward, election, 75.
Fleuss dress, 100.
Fohnsdorf coal-field (Styria), abs. 50.
Forel, F. A., earthquakes and fire-damp in mines, abs. 18.
Forster, G. B., alteration of bye-laws, 76*b*.
— *annual report*, 221.
— *exhibition of safety lamp*, 17-19.
— *federation of mining institutes*, 76*a*,
— *on variation in faulting of coal*, 54, 57.
— quoted, 35, 36.
— *steam boilers*, 227.
— *survey of Flaggy creek pit heading*, 16.
— *use of light mineral oils*, 10.
Forster, T. E., *exhibition of safety lamp*, 18.
— quoted, 31,
— *survey of Flaggy creek pit heading*, 16.
— *use of light mineral oils*, 12.
Fortune pit, Gosforth, 190.
Foster, C. Le Neve, quoted, 64.
Foxdale lead mine, 67, 70.
Francois, M., earthquakes in mines, abs. 18.
Freiburg, 67, 70.
Friction of engines, abs. 36.
Friedenshütte, boilers explosion at, abs. 25.
Fröhlich rock-boring machine, abs. 41.
Fryar, Mark, quoted, 80.

Fuel, consumption and supply on Indian railways, 157.
—, cost of, on Indian railways, 161.
—, kind of, used on Indian railways, 161.
—, source of supply on Indian railways, 161.
Fulton, John, mode of deposition of the iron ores of the Menominee range, Michigan, abs. 31.
Furnace and fan ventilation, observations on, abs. 22.
Furness district, 70.

Gad, E., some results of recent American borings, abs. 45.
Gajarine, near Conegliano, 65.
Galicia, ozokerite and petroleum in, abs. 15.
Galleguares, 66.
Gandolphi, G., the mines of Bilbao, abs. 26.
—, the mines and works of Almaden, abs. 53.
— the Belmez-Espiel coal-field (Spain), abs. 55.
Ganj Railway, 158.
Garnett, Prof., *air currents in mines*, 216, 217.
— *steam boilers*, 226.
Garrari (lepidopteris orbicularis), 130.
Gas (natural) in New York state, abs. 64.
— outbursts of, in metalliferous mines, 59, 70.
— test for carbonic oxide, abs. 55.
Gases (noxious) apparatus for detecting, abs. 68.
Gauges of Indian railways, 157.
Geological features of the Wardha valley coal-field, 77.
Geology of the Lower Congo, abs. 18, 54.
German mineral statistics, abs. 33.
Getting coal at Warora, cost of, 140, 145.
— prices of, at Warora, 133.
Ghararia caste, 116.
Ghaziabad, 159.
Ghonds, 116.
Ghugus coal-field, 80, 82, 84, 169.
Giromagny mine, 63, 64.
Glasgow barometer and thermometer readings, 229-235.
Godaveri basin, 80.
Gold and other mines in Corea, abs. 21.
— districts of the Transvaal, abs. 2.
Gold-fields of the valley of de Kaap, 171.
Golden quarry, South Africa, 172.
Gold mining in Transylvania, abs. 10.
Gonds, The, 77.
Gondwana system, 77, 78, 80.
Goolden and Co., W. T., quoted, 33.
Gosforth colliery, winning of the high main coal at, 189.
Gosman, F., nominated, 219.
Gottesgabe, Westphalia, 61.
Gotting, A., coal in Servia, abs. 64.
Grand-Saint-Jean, 63.
Great dyke, 193, 196.
— Indian Peninsular Railway, 77, 81, 84, 89, 90, 103, 138, 155, 157, 159, 160, 161, 169.
Greenwell, G. C., quoted, 42.
Grisoutite, abs. 26-28, 61.
Gross-Schirma, 64.
Grund, 64.
Gruner, E., Bilbao iron ore deposits, abs. 18.
Guibal fan, 31.
— — with conical inlet, abs. 63.
*Gully seam*, 15.
Gundershoffen, 62, 69.
Guthrie, James Kenneth, nomination, 187; election, 219.
Guy, John George, nomination, 188; election, 219.

Haase system of sinking through quicksands, abs. 29,
Habets, A., the mines of Bilbao, abs. 25.
— the Newcastle-upon-Tyne exhibition, abs. 24.
Hackney, W., quoted, 86, 168.
Hadfield pattern steel wheels, 106.
Hall, Frederick Wm., nomination, 76; election 187.

Hall, Thomas, nomination, 76; election, 187.
Hall, W. F., quoted, 4, 31.
Hallstadt, Austria, 62.
Hamilton, New South Wales, 15.
Hand-boring in India, 95.
Hanover, mining produce in 1888, abs. 37.
Harden, E. B. and J. H., construction of maps in relief, abs. 71.
Hardy picks at Warora, 119.
Hartz, Rammelsberg mine, 66, and abs. 28.
*Harvey seam*, 49, 50, 52, 56, 57.
Haswell, 55.
Haulage, wire rope, abs. 70.
Haupt, L. M., permeability of cements and mortars, abs. 21.
Head, Jeremiah, nomination, 187; election, 219.
Headlam, Dr., 198.
Hedley, W. H., *on variations in faulting of coal*, 55, 56.
— *outbursts of gas in metalliferous mines*, 71, 72.
Helson, Cyriaque, manufacture of iron and steel in Italy, abs. 24.
Henderson bars, 225.
— mechanical stoker, 224.
Henrich, Carl, a study of faults, abs. 56.
Henshaw, A. Mayon, nomination, 76; election, 187.
Herbst, —., experiments upon a Capell fan, abs. 9.
Hericart de Thury, L. E. F., quoted, 65.
Hewers' output at Warora, 121.
Heworth fault, 56.
*High main coal seam*, 189-203.
High-pressure water wheel on the Comstock, abs. 20.
Hilger, E., the northern portion of the Westphalian coal-field, abs. 3.
Hillcar sough, 60.
Hill, Geo., quoted, 195-198.
Himmelsfürst mine, 67.
Hinduri, 158.
Hinganghat Mill Company, 139, 155.
History of Warora, 84.
Hiwar or kinj (acacia eucophlea), 131.
Hodgson, John, nominated, 219.
Hoisting arrangements, abs. 7.
Hollis, Henry William, nomination, 76; election, 187.
Honorary members, xv.
Hooson, Wm., quoted, 67.
Hopper, J. I., election, 27.
Hopkins, Edward, nominated, 219.
Hucklewedge, 61.
Hucklow Edge, 60.
Hughes, —., quoted, 78, 81-83, 85, 167
Hinganghat Mill Company, 139.
— station, 80.
Hungarian mines, 67.
Hunt, Robert, quoted, 35.
Hunter, Jas., survey of Flaggy creek pit heading, 13-16.
Hutchinson, T. C., nomination, 188; election, 219.
Hyderabad, Nizam of, 81, 82, 157, 160.

Illing, C., gold and other mines in Corea, abs. 21.
Improvements in wire rope ways, abs. 10.
Inclines with intermediate landings, abs. 23.
India, coal mining at Warora, 77-169.
Indian coals, prices of, 160.
— Factories Act, 113, 133.
— iron ores, 166.
— limestones, 167.
— railways, cost of fuel on, 157, 161.
— —, description of fuel used on, 157.
— —, distribution of coal on, 161.
— —, gauge of, 157.
— —, length of, 157, 161.
— —, quantity of fuel used on, 157.
— valley railway, 160.
Indus valley railway, 162.
Internal friction of engines, abs. 36.
Ireland, —., quoted, 167.
Iron ore deposits of Bilbao, abs. 18.
— — mining, abs. 28.
— — near Warora, 165.
— — (Indian) analyses of, 166.

Iron ore of Menominee range, Michigan, mode of deposition of the, abs. 31.
Iron and steel manufacture in Italy, abs. 24.
Isherwood, —., an investigation on some experiments on a centrifugal blower, abs. 48.
Isle of Man, 67.
Italy, manufacture of iron and steel in, abs. 24.

Jabalpore, 77.
Jacques, James Routledge, nomination, 75; election, 187.
Jawari, 83.
Jicinski, B. W., sand cartridges, abs. 7.
Jeffrey air-feed drill, abs. 23.
— electric coal mining machine, abs. 67.
Jodhpore railway, 157.
Johannes Stehenden vein, 67.
Juckes bars, 223, 224, 225.
— furnace, 225, 226.
Junara, 81.

Kaap gold-fields, 174.
— valley, 171.
Kahitah, 15.
Kahle, P., a simple water level, abs. 71.
Kahu or argun (terminalia arjuna), 131.
Kali valley, 158.
Kamphi beds, 79.
Kampthis, 78, 79.
— group, 92.
Kandara, 80.
Karharbari, 89.
Kas, A., Guibal fan with conical inlet, abs. 63.
Kate or kasei (briedelis retusa), 131.
Katin-Umaria railway, 157.
Kawassa, 79.
Keni or gorarh (albizzia procera), 131.
Kenton and Coxlodge wagon-way, 194.
Kew barometer and thermometer readings, 229-235.
Khandara, 167.
Khandeshar hill, 165.
Khasia state, 158.
Khatun, near Sibi, 159.
Khost range, Afghanistan, 158.
Killingworth moor, 189.
King, T., quoted, 192, 194.
Kirkaldy, D., quoted, 165, 167.
Klein Saros in Transylvania, 61.
Klinik safety-catch for cages, abs. 16.
Klupfel, H., the Fröhlich rock boring machine, abs. 41.
Kota-Maleri group, 79.
Kunara, 81.
Kunker, 80.
Kurachi, 159, 160.
—, price of coals at, 160.
Kurhurbaree, 161-162.
— coal, value of, 161.
Kurhubari, Bengal, 78.
Kurmi caste, 116.
Kussinsk mine, Urals, abs. 2.
Labour, price of, at Warora, 148-153.

Lake Superior, 65.
Lallas caste, 116.
Lameta limestone, 167.
Lancaster, J., quoted, 32.
Larsson, P., iron ore mining, abs. 28.
Lawrence, H., *steam boilers*, 225, 226, 227.
Leach, C. C., *exhibition of safety lamp*, 18.
— scrutineer, 219.
Lead mines, Derbyshire, 59, 67, 69.
— smelting in Peru, abs. 11.
Leaton, John, quoted, 190.
Lebour, Prof., *alteration of bye-laws*, 76a, 76b, 185.
—, *federation of institutes*, 47, 76.
—, *notes on variation in faulting of coal*, 54, 55.
—, quoted, 39.
—, *outbursts of gas in metalliferous mines*, 72.
—, *use of light mineral oils*, 9.
—, *winning of the high main seam at Gosforth*, 203.
Length of Indian railways, 157.
Lesmahago Coal Co., 32.
Library, 42.

Liddell, J. M., gold-fields of the valley of de Kaap, 171, 175.
— *outbursts of gas in metalliferous mines*, 72.
Light mineral oils, 3-12.
Limestones (Indian), 167.
Littletown, 55.
Liverton mine, near South Skelton, 71.
Llanidloes, 64.
Llyndu coking coal, 86.
— colliery, near Bridgend, 86.
Lobombo range, 171.
Lohara hill, 165.
— iron ore, 165, 167.
Lohmann, H., experiments with explosives, abs. 56.
Lombardy, Conegliano, 65.
— Gajarine, 65.
Longwall system, 31.
Lower Congo, geology of the, abs. 18, 54.
— Gondwana, 78.
— Silesia, coal mining industry of, abs. 17.
— Silurian, 64.
— Vindhyan, 78.
*Low main seam*, 55.
Luders, Rich., Klinik safety catch for cages, abs. 16.
Lueg, H., the sinking of the shafts in water-bearing strata, abs. 3.
Luttermann, —., dressing ore rolls in position, abs. 12.

Macdonald, —., quoted, 98.
Macfarlane, T., quoted, 65.
Madagascar, coal in, abs. 69.
Maddison, Thos. Robert, nominated, 219.
Madras, price of coal at, 160.
Madras railway, 157, 160, 162.
*Main coal seam*, 55.
Majri, 80.
Makonjwa range, 171.
Makum coal-fields, 158.
Malagarh hill, 79.
Maleri, 79.
*Mammoth coal seam*, abs. 5.
Manganese in Bosnia, abs. 66.
Manufacture of coke, 40.
— — — in Westphalia, abs. 4.
— — iron and steel in Italy, abs. 24.
Maps, construction in relief, abs. 71.
Marathi language, 124.
Mareschal, J., pump with captant piston, abs. 70.
Marley, J., *air currents in mines*. 216, 217, 218.
—, *alteration of bye-laws*, 76a, 76b, 183, 184, 185, 220.
—, *British Association meeting*, 220.
—, *coal mining at Warora, East India*, 169.
—, *exhibition of safety lamp*, 17-19.
—, *federation of mining institutes*, 76, 76a, 220, 221.
—, *notes on variation in faulting of coal*, 53, 56-58.
—, *outbursts of gas in metalliferous mines*, 71, 72.
—, presidential address, 29-46.
—, resolution of council, 47.
—, *survey of Flaggy Creek pit heading*, 16.
—, *the Pieler spirit lamp*, 182a, 182b.
—, *use of light mineral oils*, 9, 12.
—, *winning of the high main coal at Gosforth*, 201, 203.
Marmaros county, Hungary, 61.
Massa Maritima, 67, 70.
Mather and Platt system of boring, 94.
Mayo, Lord, quoted, 81.
Mayo pit, 81.
Mechanical slate-picker, abs. 20.
Membership question, iii., 220.
Members, v., xviii; associate members, xxxi; associates, xxxi; students, xxxii.
Menominee range, Michigan, iron ore of, abs. 31.
Merivale, Prof. J. H., *on variation in faulting of coal*, 53, 54, 55.
—, *the Pieler spirit-lamp*, 182, 182a.
Metalliferous mines, outbursts of gas in, 59-70.
Metal rolling machine (Simonds), abs. 48.
Metallurgy, &c., in Belgium in 1884 and 1885, abs. 57.

Meyer, Johann, grisoutite, abs. 61.
—, system of firing shots, abs. 62.
Meysey-Thompson, A. H., election, 75.
Michigan, mode of deposition of the iron ores of the Menominee range, abs. 31.
Mill close, Darley, 59, 60, 61, 69.
Mineral oils, 3-12.
— products of New South Wales, abs. 61.
— statistics (German), abs. 33.
— — (Swedish), abs. 46.
Mines and works of Almaden, abs. 53.
— of Bilbao, abs. 25, 26.
— in Corea, abs. 21.
—, earthquakes and fire-damp in, abs. 18.
—, moisture of the air in, abs. 34.
Mining (coal) at Warora, East India, 77-169.
— (gold) in Transylvania, abs. 10.
— in large bodies of ore, abs. 30.
— produce, Dortmund, &c., in 1888, abs. 37.
— in Pennsylvania, waste in, abs. 5.
— schools in Prussia, abs. 3.
— statistics, Belgium, in 1884-85, abs. 57.
Mining engineers, course of instruction, v., xiii.
Mode of deposition of the iron ores of Menominee range, Michigan, abs. 31.
Model hoisting arrangements, abs. 7.
Mohka (schrebera swietenoides), 130.
Mohpani coal, price of, 160.
— —, value of, 161.
— colliery, 159.
Mohwa (bassia latifolia), 131.
Moisture of the air of mines, abs. 34.
Mollau, Alsace, 69.
Monte Catini mine, Tuscany, 64, 69.
Morison, J., the danger attending the use of light mineral oils, 3-12.
Mortars, permeability of, abs. 21.
Müller, H., quoted, 67.
Murday, T. J., exhibition of apparatus for obtaining readings from indicators at a distance, 72.
Mueseler lamp, height of cap, 181.
Mysore railway, 157.
Nagpore, 77.
Nagpur, 79.
Nandgaon, 160.
Nanduri, 80.
Nasse, R., on the moisture of the air of mines, abs. 34.
Natural ferric sulphates in Chile, abs. 2.
Natural gas in New York state, abs. 64.
Nerbudda valley, 77.
Ness, W., quoted, 98, 165, 167, 168.
Newbattle colliery, Dalkeith, 4, 6.
—, *use of light mineral oils at*, 8.
Newcastle-upon-Tyne exhibition, abs. 24.
— — — British Association meeting, 47, 220.
New Lambton colliery, New SouthWales, 15.
New South Wales, Flaggy Creek pit heading, 13-19.
— — —, mineral products, abs. 61.
New York State, natural gas in, abs. 64.
Nil desperandum, South Africa, 172, 173.
Ninety-fathom dyke, 189.
Nizam of Hyderabad, 81, 82, 157, 160.
Nokora, 81.
Northern Bengal railway, 160, 162.
North Gosforth colliery, 192.
Northumberland, county of, New South Wales, 15.
North Western railway, India, 157, 160.
Notes and reports on the winning of the high main coal at Gosforth colliery, 189.—An estimate of the expence of working Gosforth colliery, 189.—Expence of working landsale colliery with 11 peck corf, 189.—View of Gosforth colliery, 21 March, 1753, 190.—Report on 28 Jany., 1807, 191.—Estimate of the expence of laying a score of 16 peck corves upon bank upon a vend of 10,000 fothers yearly, 191.—Estimate of sinking a new pit, January, 1807, 191.—Expence of winning the coal by widening the Quarry pit shaft, January, 1807, 191.—Estimate of winning North Gosforth col-

liery, Feb. 1806, 192.—Estimate of the expence of working Gosforth colliery on a vend of 8,000 chals. per annum, 192.—Estimate of winning the high main coal, 1816, 193.—John Watson's report, 19 Dec., 1816, 193.—Report on the different modes by which a winning of the high main coal might be accomplished, Jany. 19, 1824, 195.—Report 10 Nov., 1826, 196.—Report 13 Aug., 1827, 197.—Discussion, 200-203.
Notes on variations on the faulting of coal, 49-52.—Discussion, 52-58.
Nottingham colliery, Pennsylvania, abs. 6.
Noxious gases, apparatus for detecting, abs. 68.

Observations on the furnace and fan, and mine ventilation, abs. 22, 23.
Officers, xvii.
Ore rolls, dressing, in position, abs. 12.
Ore washing, settling ponds, abs. 12.
Orville, Gustav D., apparatus for detecting noxious gases, abs. 68.
Oude railway, 159.
Oudh and Rohilkund railway, 161.
Outbursts of gas in metalliferous mines, 59-70.—discussion, 70-72.
Output per man at Warora, 120,
— of Warora, 138, 156.
Ozokerite, abs. 68.
— and petroleum in Galicia, abs. 15.

Palmer, Eli J., quoted, 17.
Papur, 82.
Parsora, 81.
Passi caste, 116.
Patent fuel (English), value, 161.
Patrons, xv.
Patterson, T., election, 75.
Pearson, G. T., Seaton Carew boring, 21.
Pelton high-pressure water-wheel and dynamos on the Comstock, abs. 20.
Penck, —, the island of Corfu, abs. 22.
Pennsylvania, Nottingham colliery, abs. 6.
—, waste in mining in, abs. 5.
Perino, Josef, extraction of copper from pyrites, 32.
Permeability of cements and mortars abs. 21.
Permian, 78.
Persons employed at Warora, 137.
Peru, lead smelting in, abs. 11.
—, Potosi, 65.
Petroleum in Galicia, abs. 15.
—, &c., in New York state, abs. 64.
— wells at Khatun, 158.
Physical geography of Warora, 83.
Pieler, —, quoted, 177.
— spirit lamp, 177.
— height of cap, 181.
— discussion, 182-182*b*.
Pilkington, 60.
Pipalgaon, 165, 166.
Pisgaon, 81, 169.
Pittington, 55.
Plom and D'Andrimont system of blasting, abs. 65.
Plot, Robert, quoted, 62.
Plummer, John, nomination, 76; election, 187.
Poech, —, manganese in Bosnia, abs. 66.
Poland, Wieliczka in, 61.
Pontpéan in Brittany, 63, 70.
Port Waratah, New South Wales, 15.
Potosi, 65, 66.
Posepny, F., quoted, 62.
Pranhita basin, 80, 81.
Presidential address by Mr. John Marley, 29.—Royal coal commission, 1871, 30.—Accidents in mines, 30.—Long-wall system, 31.—Fans, 31.—Electrical and other coal-cutting machines, 32.—Boiler explosions, 35.—Colliery warnings, 35.—Coal-dust, 36.—Explosive agents, 36.—Steavenson's hydraulic drill in Cleveland, 36.—Ramsay wedge, 36.—Safety-lamps, 37.—Safety-hooks, 37.—Transmission of power.—37.—Geological, 39.—Coke ovens, 40.—Coke, 40.—Library, 42.—Federation of various mining institutes, 42.—Finance, 43.—Trivial points, 44.
Price of coal at Kurachi, 260.

Price of coal at Madras, 160.
— — English coal in India, 160.
— — Indian coal, 160.
— for getting coal at Warora, 138.
Price of labour at Warora, 148, 153.
Prices (selling) of Warora coal, 138.
Primat, —, earth tremors, abs. 46.
— quicksilver in Tuscany, abs. 14.
Proctor, John Henry, nomination, 76; election, 187.
Prussia, mining schools in, abs. 32.
Prussian fire-damp commission, 179.
Prussian mines, wages in, abs. 65.
Prussia (Rhenish), mining produce in 1888, abs. 37.
Prytherch, H. O., quoted, 13.
Pumping arrangements at Warora, 107.
Pump, with captant piston, abs. 70.
Punjaub railway, 159.
— Northern railway, 162.
—, salt range of the, 158.
Pyrites, extraction of copper from, abs. 32.
— in bituminous coal, abs. 71.

Quarry pit shaft, 191.
Queen's river, 175.
Quicksands, Haase system of sinking through, abs. 29.
Quicksilver in Tuscany, abs. 14.
— mines of New Almaden, California, abs. 8.

Railways (Indian), gauge of, 157.
— —, length of, 157.
— —, fuel consumed by, 157, 161.
— —, cost per ton of fuel, 157, 161.
— —, description of fuel used, 157.
— —, distribution of coal on, 161.
— using Warora coal, 139, 155.
Rainfall of Warora, 83.
Rajputana Malwa railway, 157, 160, 162.
Rammelsberg mine, 66, abs. 28.
Rampore coal-field, 158.
Ramsay, J. A., *the Pieler spirit lamp*, 182, 182*b*.
Ramsay wedge, 36, 37.
Raniganj coal, 159, 160.
— coal-field, 78, 105, 107.
Raoult, Chas., the Beer wire rope way, abs 23.
Rates for contract work at Warora, 164.
Ratnapur, 165.
Records of earth tremors committee, 43.
Redheugh colliery, faulting of coal at, 49-58.
Redmayne, R. Norman, nominated, 219.
Rehhübel, 63.
Report of the council, iii.
— — finance committee, viii.
Rewah (Umaria) coal, price of, 160.
— — —, value of, 161.
Rhenish Prussia, mining produce in, 1888, abs. 37.
Rhodes, —, quoted, 17.
Richards, T. J., quoted, 3.
Richardson and Watts, quoted, 70.
Rigud and Guinard, coal in Madagascar, abs., 69.
Riley, E., quoted, 80, 87, 90.
Roberts, Charles Warren, election, 75.
Roberts, Frank C., wire rope haulage and its application to mining, abs. 70.
Robinson coal-washer, 45.
Robson, T. O., notes on variations in faulting of coal, 49-58.
Rocca Federighi in Tuscany, 63, 69.
Rock-boring machine, Fröhlich, abs. 41.
Rock pressure, abs. 64.
Rohan (soymida febrifuga), 131.
Rohilkund railway, 159.
Rolland, Camille, test for carbonic oxide gas, abs. 55.
Ross, J. A. G., *steam boilers*, 224.
Rothwell, R. P., mining in large bodies of ore, abs. 30.
Royal coal commission, 30.
— Saxon mining bureau, 63.
Ruidant, Chas., inclines with intermediate landings, abs. 23.
Rules, 43, 44.
Ryhope colliery, New South Wales, 15.

Safety catch for cages, Klinik, abs. 16.
— hooks, 37.
— lamps, 37, abs. 38, 41.
— lamp, the Pieler, 177, 181
— — exhibited and discussed, 17-19.
Saimbal, 80.
Saj (terminalia tomentosa), 131.
Salter's bridge, bore-hole at, 189.
Salt mines, explosions in, 61.
— range of the Punjaub, 158.
— in South Durham and Cleveland, 39, 40.
Sampson post lever, 94.
San Christoval de los Lipes, 65.
Sancta Juanna, 66.
Sand cartridges, abs. 7.
Sandwich, Earl of, quoted, 65.
Sandycroft battery, 175.
Sarti, 82.
Saunders bar channeler, abs. 20.
Saxony, artesian wells in, abs. 13.
— Freiberg, 67.
Saxon mines, 67, 69.
Saxony (Prussian) Stassfurt in, 61.
Schaffhausen falls, 39.
Schiele fan, 31.
Schladebach, boring at, abs. 1.
Schönborn, 64.
Schondorff, Dr., benzine lamps in coal mines, abs. 4.
— experiments upon the Boty safety-lamp, abs. 38.
— experiments upon various forms of, abs. 41.
Schools (mining) in Prussia, abs. 32.
Shropshire, Snailbeach lead mines, 69,
Schulz, W., Plom and D'Andrimont system of blasting, abs. 65.
Schwarenberg district, 63.
Scottish Australian Mining Company, 15.
Seaton Carew boring, 21-25.
Securite, abs. 64.
Seena (lagerstromia pariflora), 130.
Servia, coal in, abs. 64.
Settling ponds used in ore and coal-washing, abs. 12.
Shaft sinking in water-bearing strata, abs. 3.
Shamnagar station, 159.
Shaw, Saville, election, 75.
— *the Pieler spirit lamp*, 182.
Sheafer, P. W., waste in mining in Pennsylvania, abs. 6.
Sheba Gold Mining Company, Limited, 172.
— Hill, 171, 172.
— lode, 174.
Shireoaks colliery, 19.
Shore, William Martin, election, 75.
Short, Dr. T., quoted, 60.
Shots, system of firing, abs. 62, 66.
Sicily, sulphur mines, abs. 50.
Siemens, S., quoted, 167.
Silicia (Lower) coal mining industry, abs. 17.
Silver Islet, 69.
— — — mine, 65.
Simmersbach, F., the manufacture of coke in Westphalia, abs. 4.
Simonds universal metal-rolling machine, abs. 48.
Simpson, J. B., *alteration of bye-laws*, 185.
— *on variation in faulting of coal*, 52, 55, 56, 57.
— quoted, 39.
— *winning of the high main coal at Gosforth*, 201, 202.
Sind railway, 159.
— Punjab and Delhi railway, 161.
— Pishin railway, 158.
Singareni, 158.—Coal, 169.
— price of coal, 16.
— value of coal, 161.
Sinking through quicksands, abs. 29.
— in water-bearing strata, abs. 3.
— at Warora, 92, 93.
Siras (albizzia lebbak), 131.
Sitarampur, 161.
Slate-picker, mechanical, abs. 20.
Smith, Edw., quoted, 189.
Smith, Norman, nomination, 76; election 187.

Snailbeach lead mine, 69.
Snelus, G. J., quoted, 165-168.
Snelus and Riley, Messrs., quoted, 85, 86.
South Africa, 72, 171.
— Indian railway, 158, 160, 162.
— Skelton iron mine, 71.
— Wales, 85.
Spain, Belmez-Espiel coal-field, abs. 55.
Spontaneous combustion, 90, 97-104.
Sprague, F. J., the transmission of power by electricity, abs. 35.
Sprenger, J., improvements in wire rope ways, abs. 10.
St. Amorin in the Vosges, 69.
Stanley coal heading machines, 158.
Stansfeld, H. S., election, 1.
Stanton, P., election, 27.
Stassfurt, in Prussian Saxony, 61.
Statistics, German mineral, abs. 33.
— of mining, metallurgy, &c., in Belgium in 1884-85, abs. 57.
Steam boilers at collieries, economical working of, discussion, 223-228.
— —, water for, abs. 60.
— boring in India, 95.
Steavenson, A. L., *exhibition of safety lamp*, 19.
— hydraulic drill in Cleveland, 36.
— *outbursts of gas in metalliferous mines*, 71.
— quoted, 40.
— *steam boilers*, 223, 224, 226.
— *the Pieler spirit lamp*, 182, 182*a*.
— *use of light mineral oils*, 9, 10, 12.
Steel and iron manufacture in Italy, abs. 24.
Stella Coal Company's colliery, 121.
Stelsner, A. W., the Transvaal gold districts, abs. 2.
Stephenson lamp, 37.
Stinking mine, 66.
St. Johannes mine, 63.
Stoke Sough, 60.
Stokes, A. H., quoted, 59.
Stores, cost of, at Warora, 162.
Straker, Jno., quoted, 192, 196, 197.
Stratton, T. H. M., *alteration of bye-laws*, 185.
— *steam boilers*, 228.
— *use of light mineral oils*, 10.
— *winning of the high main coal at Gosforth*, 202, 203.
Streatfield, Hugh Sidney, nomination, 76 ; election, 187.
Students, xxxii.
Styria, Fohnsdorf coal-field, abs. 50.
Subscribing collieries, xxxiv.
Subscriptions, account of, viii.
Sulphur mines of Sicily, abs. 50.
Supply of coal to Indian railways, 157.
Survey of Flaggy creek pit heading, 13.
Suria (xyla dolabriformis), 131.
Svedmark, Eug., Swedish mineral statistics, abs. 46.
Sweden, Falun mine, 66.
Swedish mineral statistics, abs. 46.
Swete, Oswald, exhibition of safety lamp, 17-19.
Switzerland, Bex salt mine, 61.
Szlatima mine, Marmaros county, Hungary, 61.

Tail rope commission, 38.
Talchirs, 78, 79, 94.
Taylor, J. quoted, 39.
Taylor, W. N., quoted, 38.
Thendu (diospyros melanoxylon), 130.
Thermometer readings, 229-235.
Thilo, E., gold mining in Transylvania, abs. 10.
Thornley, 55.
*Three-quarter seam*, 51.
Thurston, R. H., on the distribution of internal friction of engines, abs. 36.
Thury, L. E. F. Hericart de, quoted 65.
Timber, cost of, at Warora, 130.
—, sort of, used at Warora, 131.
Tittel, —., quoted, 63.
Tools used at Warora, 119.
Topley, Wm., nominated, 219.
Towcester, 165.

Towneley colliery, 52, 55.
*Towneley seam*, 52, 55, 56.
Transmission of power, 37.
— — —, by electricity, abs. 35.
Transvaal gold districts, abs. 2.
—, gold-fields of the Valley of de Kaap, 171.
Transylvania, Klein Saros, 61.
—, gold mining in, abs. 10.
Troughton and Simms, 13.
Tschernyschew, Th., the Kussinsk mine in the Urals, abs. 2.
Tuscany, Massa Maritima, 67.
— Monte Catini mine, 64, 69.
—, quicksilver in, abs. 14.
— Rocca Federighi, 63.
Tween, —., quoted, 85.

Umaria coal, value of, 161.
— colliery, 107, 156, 158, 169.
Underground fires in India, 97-104,
— work at Warora, 113.
Unthank, Ra., quoted, 190.
Upper Burma, 158.
— Erzgebirge, 67.
— Gondwana, 78, 79.
— Hartz, 64.
Urals, Kussinsk mine, abs. 2.
Urbanus adit level, 63.
Ures dictionary, quoted, 10.
Use of light mineral oils, 3-9.
— discussed, 9-12.

Value (comparative) of different kinds of coal, 161.
— of Indian coals per ton, 160.
Van mine, 64, 69.
Vasey, T. W., election, 1.
Vaud, Switzerland, 61.
Ventilating fan, Capell, abs. 9.
Ventilation, observations on furnace and fan, abs. 22.
— at Warora, 110.
Verenguela de Pacages, 66.
Vickers bars, 223.
Vindhyan limestone, 167.
Vosges, St. Amarin, in the, 69.
Voulte mine, 62, 70.

Wabner, R., settling ponds used in ore and coal washing, abs. 12.
Waddell, Dr., quoted, 88.
Waddle fan, 31, 110, 112.
Wages in Prussian mines, abs. 65.
Walker Bros., 16.
Walker, Wm., Jun., nomination, 187; election, 219.
Warangal, 169.
Waratah Coal Company, 13.
Warden, —., quoted, 87.
Wardha junction, 77.
— Pranhita-Godaveri basin, 77, 82.
— river, 77, 79, 84.
— coal state railway, 77, 80, 84, 105, 139, 140, 155, 157.
— coal state railway office, 126.
— valley, 77, 78, 79, 81.
— — coal-field, 77, 78, 79, 85, 88, 153.
Warora, coal mining at, 77-169.
Waste in mining in Pennsylvania, abs. 5.
— in working the coal at Warora, 129.
Water-bearing strata, sinking of shafts in, abs. 3.
Water level, 189, abs. 71.
— for steam boilers, abs. 60.
— wheel (high pressure) on the Comstock, abs. 20.
Watson, John, quoted, 190-197.
Weeks, J. G., *alteration of bye-laws*, 183 184.
Weightman, Percy Octavius, nominated, 219.
Weight of a cubic foot of coal, abs. 67.
Wells (artesian) in Saxony, abs. 13.
Westphalia, Gottesgabe in, 61.
—, manufacture of coke in, abs. 4.
—, mining produce in 1888, abs. 37.
Westphalian coal-field, northerly portion of, abs. 3.
White, H., *outbursts of gas in metal liferous mines*, 71, 72.

Wicliczka, in Poland, 61.
— gases, 70.
Williams, observations on furnace and fan ventilation, abs. 22.
Willis, James, *air currents in mines*. 216, 217, 218.
— *the Pieler spirit lamp*, 182*b*.
— *outbursts of gas in metalliferous mines*, 70-72.
Wilson, Arthur Prangley, nomination, 188; election, 219.
Wilson, J. D., *the Pieler spirit lamp*, 182*a*
Winckel, 62, 64, 69.
Wingate Grange colliery, 45.
Winning of the high main coal at Gosforth colliery, 189-203.
Wire rope haulage, abs. 70.
— — way, abs. 23.
— — ways, improvements in, abs. 10.
Wolf lamp (benzine), height of cap, 181.
Wood, John, nomination, 76; election, 187.
Wood, Harrie, mineral products of New South Wales, abs. 61.
Wood, Lindsay, *presidential address*, 45.
— quoted, 31, 38.
Wood, Nicholas, quoted, 29, 39, 42.
Working of Warora colliery, cost of, 143 147.
Wun, 81, 82.

*Yoredale shales*, 60, 67, 69.
Youlgreave, 60, 67.
Young, Prof. J., quoted, 41.

Zagra, 81.
Zboinski, H., geology of the Lower Congo, abs. 18.
Zugo, Transylvania, 61.

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